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Published by THE OTTAWA FIELD-NATURALISTS' CLUB, Ottawa, Canada

Volume 119, Number 1 **January–March 2005**

The Ottawa Field-Naturalists' Club

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The Canadian Field-Naturalist

The *Canadian Field-Naturalist* is published quarterly by The Ottawa Field-Naturalists' Club. Opinions and ideas expressed in this journal do not necessarily reflect those of The Ottawa Field-Naturalists' Club or any other agency.

PAP Registration Number 9477. Canada We acknowledge the financial support of the Government of Canada through the Publication Assistance Program (PAP) toward our mailing costs.

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COVER: Gray Jays, *Perisoreus canadensis*, feeding on White-tailed Deer, *Odocoileus virginianus* carcass near Ely, Minnesota. See paper on weight-carrying ability and caching behavior by Lynn L. Rogers page 101-104.

THE CANADIAN FIELD-NATURALIST

Volume 119

2005

Volume 121
The Ottawa Field-Naturalists' Club Transactions)

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The Canadian Field-Naturalist

Volume 119, Number 1 January–March 2005

Chronology of Range Expansion of the Coyote, *Canis latrans*, in New York

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Fener, Heather M., Joshua R. Ginsberg, Eric W. Sanderson, and Matthew E. Gompper. 2005. Chronology of range expansion of the Coyote, *Canis latrans*, in New York. Canadian Field-Naturalist 119(1): 1-5.

Coyotes (*Canis latrans*) were historically restricted to central North America. In less than two centuries, however, Coyotes have colonized most of the continent, including much of northeastern North America. Better understanding causes and proximate mechanisms of this expansion requires a detailed understanding of how Coyotes colonized areas on a fine scale. We examined the establishment of Coyotes in the State of New York by collecting and analyzing reports of their first occurrence throughout the state over the past century, and creating a detailed map of range expansion. Coyotes first entered New York from the north, circled the Adirondack region prior to colonizing it, and then expanded southward and westward at ca. 78-90 km/decade. The revealed pattern lends little support to the hypotheses that the range expansion is attributable to translocations and releases, or that Coyotes were historically present in the region and only recently expanded in numbers. Rather, the data suggest a correlative relationship between anthropogenic land use and Coyote range expansion.

Key Words: Coyote, *Canis latrans*, range expansion, northeastern North America, landscape change, land use.

The Coyote (*Canis latrans*) is one of the most widely disturbed and successful colonizing mammals in recent history. Traditionally restricted to the open grasslands and praire ecosystems of Midwestern North America, today the Coyote is found throughout most of North America (Bekoff and Gese 2003). Eastern North America has been almost entirely colonized by Coyotes, which have become a numerically and ecologically important member of the predator community (Parker 1995; Gompper 2002a, b).

In northeastern North America, sporadic reports of Coyote-like canids in northern New England, New York, and the southeastern Canadian provinces of Ontario and Québec began in the early 1900s (Hilton 1978; Moore and Parker 1992; Parker 1995; Gompper 2002b). Through the 1930s and 1940s these reports became more frequent, and by the 1980s the Coyote was firmly established and widespread throughout the Northeast (Parker 1995). Several explanations may explain this broad and rapid range extension. Gray Wolf (*C. lupus*) extirpation throughout most of eastern North America in the 19th century is thought to have created an empty ecological niche ripe for exploitation (Parker 1995; Peterson 1996; Gompper 2002b). Extensive modification of the landscape through deforestation and agricultural development may also have facilitated range expansion (Larivière and Crête 1992; Parker 1995). Importation and release of Coyotes into areas where they were previously nonexistent may also have aided their establishment in some regions (Parker 1995). Finally, some argue that Coyotes were always present in the Northeast, albeit in low numbers (Tullar 1992).

Current maps depicting Coyote range expansion (e.g. Parker 1995) are ideal for visualizing continental-scale range expansion, but a finer scale resolution may assist in comparing the explanations for the current existence of Coyotes in the Northeast, and provide insights into the proximate mechanisms by which Coyote populations expanded across the northeastern landscape. That is, how did these animals move through and establish themselves in the Northeast in such a relatively short period? Here we create a detailed (county-level) map of Coyote range expansion in the State of New York, and examine potential causes and mechanisms of this expansion.

Methods

To establish the Coyote colonization pattern and direction of their range extension in New York on a spatial and temporal scale, first occurrence reports and documented sightings of Coyotes were collected dating back to circa 1900. Because Coyotes were rare and undesirable newcomers in the region in the early 20th century, we believe these reports accuratly depict both

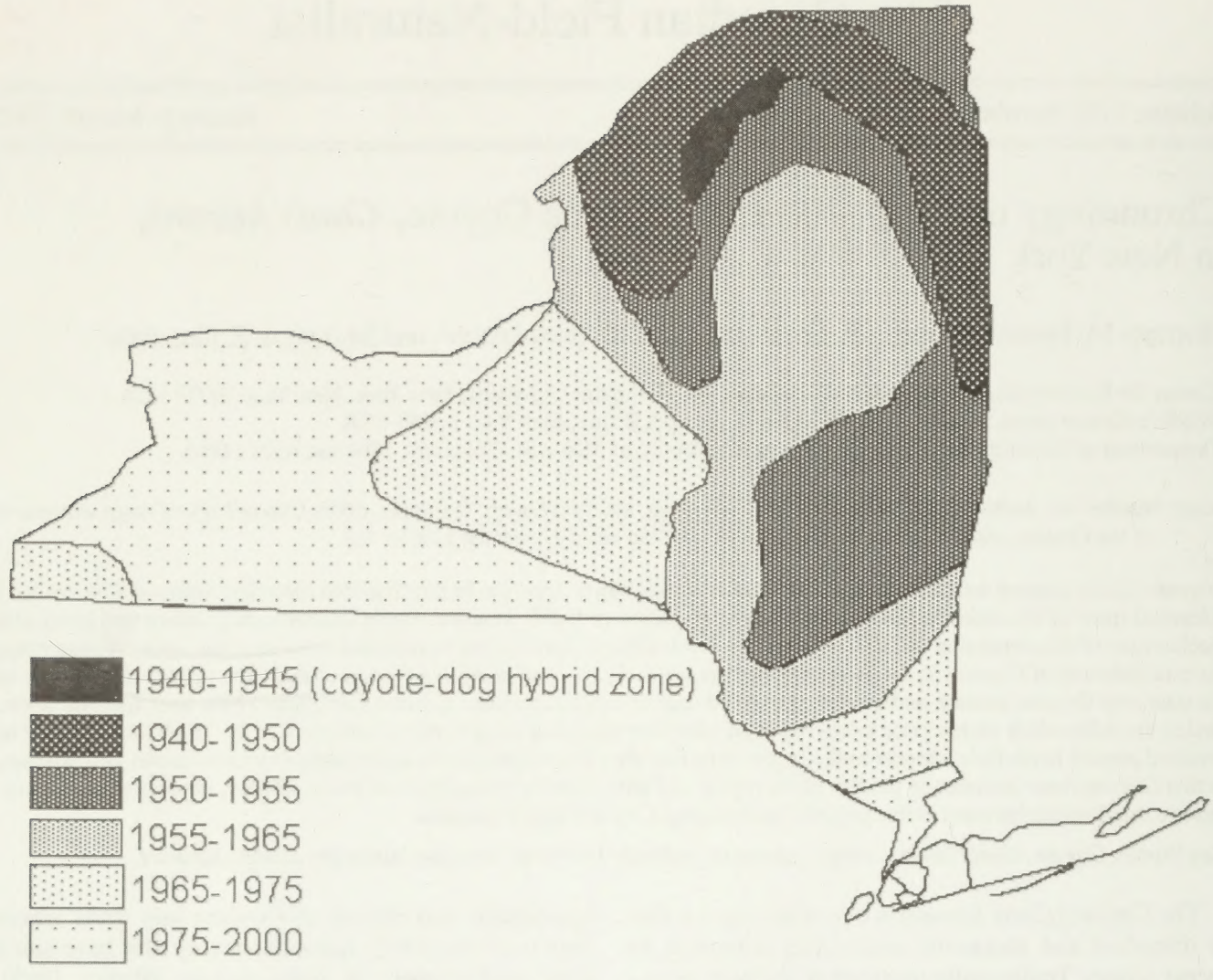

FIGURE 1. Coyote colonization pattern in New York between 1940 and 2000. A putative Coyote-feral dog hybrid population which existed along the northwestern edge of the Adirondacks is also indicated.

presence and absence in particular areas and their movement across the state. County newspapers, regional outdoor magazines (e.g., *Adirondack Life, New York State Conservationist, and Fur, Fish & Game*), and regional scientific journals (e.g., *New York Fish and Game Journal*) were examined for reports of Coyotes (time frame of search: 1880 – 2000), as were archives and collections of the American Museum of Natural History and the New York State Museum.

County Clerks' offices in northeastern New York (Albany, Clinton, Essex, Franklin, Fulton, Hamilton, Herkimer, Lewis, Jefferson, Madison, Montgomery, Otsego, Rensselaer, Oswego, Saratoga, Schenectady, Schoharie, St. Lawrence, Warren, and Washington counties) were visited and canid bounty records and laws from the late 1800s and early 1900s were examined. In 2000 and 2001, field station, park, and preserve personnel from throughout New York east of and including Oswego, Oneida, Madison, Chenango and Broome counties, where contacted to establish timing of Coyote establishment in their respective sites, and interviews (n = 38 individuals who were active with Coyote-related issues during the early stages of Coyote colonization) were conducted, with current and retired state biologists, wildlife technicians, university researchers, game wardens, professional trappers, hunters, taxidermists, fur buyers, and sheep farmers throughout eastern New York State (Fener 2001).

From this data set a series of geographic information system data layers were created using ArcView/GIS mapping software (Environmental Systems Research Institute, Redlands, CA). Coyote reports were aggregated by county and by decade over the last 100 years, and then attributed to the county polygons in the GIS.

Results and Discussion

Coyotes became established in northern New York in the early 1940s (Figure 1). Prior to that there were occasional reports of Coyotes in the region; the earliest report is of a single individual from Franklin County in 1925 (Severinghaus 1974). In the early-mid 1930s Coyotes are again reported from Franklin County as

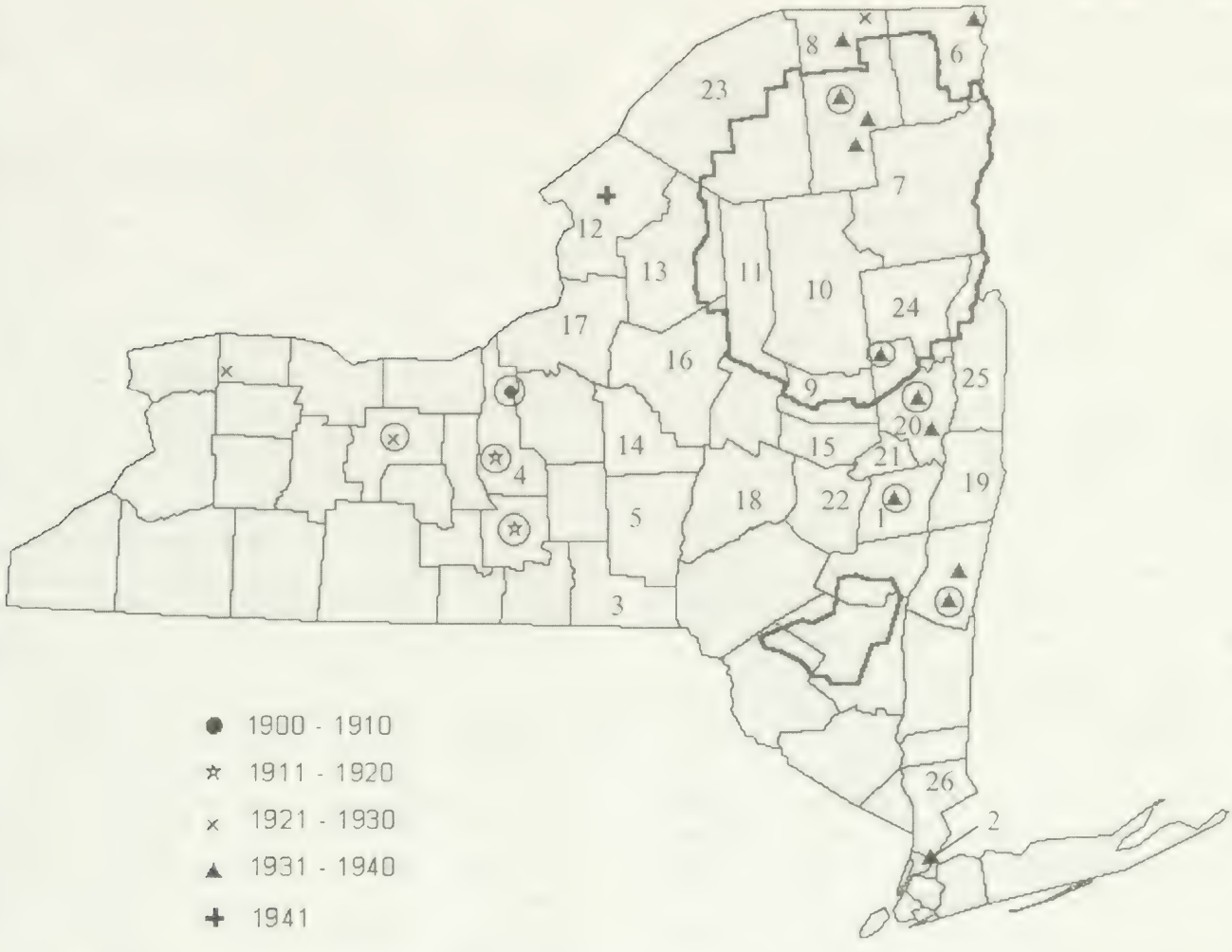

FIGURE 2. Localities of reports of Coyotes that were likely introduced or released in New York. Symbols indicate decade in which Coyotes were reported. Circled symbols indicate known releases. Non-circled symbols were likely released animals based on proximity to known release sites. These original reports were all followed by extended periods of absence of Coyotes from the regions. Counties mentioned in text are numbered (1. Albany; 2. Bronx; 3. Broome; 4. Cayuga; 5. Chenango; 6. Clinton; 7. Essex; 8. Franklin; 9. Fulton; 10. Hamilton; 11. Herkimer; 12. Jefferson; 13. Lewis; 14. Madison; 15. Montgomery; 16. Oneida; 17. Oswego; 18. Otsego; 19. Rensselaer; 20. Saratoga; 21. Schenectady; 22. Schoharie; 23. St. Lawrence; 24. Warren; 25. Washington; 26. Westchester). Dark lines outline Adirondack State Park in northern New York and Catskill State Park in southern New York.

well as neighboring Clinton County to the east. It is unclear, however, if these pre-1940s reports are valid (see below). Nonetheless, following the initial entry into New York from Québec or Ontario over the St. Lawrence River, Coyotes extended their range east into Vermont, and southwest along the St. Lawrence River towards Lake Ontario. This expansion occurred primarily along the periphery of Adirondack State Park, and in the early 1940s there was reportedly also a Coyote-domestic dog ("coydog") hybrid zone along the northwestern periphery of the Adirondacks (Fener 2001; see also Severinghaus 1974) (Figure 1). By the early 1950s the range had expanded south along the New York/Vermont border and west back into New York State into the Albany area south of the Adirondacks. Coyotes did not show up in the Adirondacks in appreciable numbers until the late 1950s. In the 1960s, Coyotes were reported with increasing frequency in the Catskill region, and by the early 1970s had moved as far west as Cayuga County and as far south as Westchester County. In the 1980s Coyotes were commonly found throughout the state, excluding New York City and Long Island. In the 1990s Coyotes occurred in Bronx County of New York City, and a transient individual reached Central Park in Manhattan in 1999. As of 2002, only Long Island in southeast New York was not colonized by Coyotes.

Coyotes colonized the ca 470 km North-South axis of New York in 60 yrs (1940-2000), or approximately 78 km/decade. Excluding New York City, Coyotes colonized the entire region (ca 450 km) by 1990 (90 km/yr). Periods of maximal range extensions include 1950-1960 when Coyotes expanded approximately 190 km southeast, and 1970-1980 when Coyotes expanded westwards by approximately 145 km. Estimating rates of range expansion in western New York are compli-

cated by the mixing of two expanding fronts. The original front of range expansion from northern New York via northern Ontario or Québec resulted in Coyotes throughout eastern New York in the 1960s and west-central New York in the 1970s. A second colonization wave apparently entered New York from southern Ontario or northwestern Pennsylvania in the late 1960s-early 1970s (Figure 1). These two colonizing fronts met, such that by the 1980s all of western New York was occupied by Coyotes.

Our results support the premise that Coyotes colonized New York through a range expansion from outside the region, and not via expansion of a low-density population already existing in the state (Tullar 1992). Indeed, Parker's (1995; pages 23-24) review of Coyotes in Ontario shows that the province was colonized in the 1920s and 1930s, suggesting Ontario, rather than Québec (colonized in the early 1940s; Parker 1995) as the source for the northern New York range expansion. There is minimal support for a colonization of New York prior to the 1930s, as most reports between 1900 and 1930 were of released animals or occurred near sites of known releases (Figure 2; see also Fener 2001). In addition, Coyotes remained absent from areas in which they were initially encountered in the 1920s and 1930s for several decades thereafter. The possible exceptions to this are reports from the mid 1920s-early 1930s in far northern New York (see below). Two primary areas of Coyote releases occurred. Four of five reports of Coyotes in west-central New York between 1900 and 1930 can be linked to releases (Figure 2). In east-central New York there are six reports of Coyotes from the 1930s, four of which are directly linked to releases. Following these reports, however, Coyotes are not reported from these regions until the 1960s and the 1950s, respectively (Figure 1). Similar patterns have been observed in the southeastern United States, where some releases may have resulted in the establishment of isolated, local populations, but many other releases did not (Hill et al. 1987).

Two additional releases in northern New York deserve special attention because of their temporal and spatial proximity to the expanding Coyote front of the 1940s. These releases occurred in Franklin (1934) and Jefferson (1941) counties. In Jefferson County, the release occurred after Coyotes had already colonized northern New York. Thus the release may have facilitated the range expansion in counties east of Lake Ontario. The Franklin County release of 1934 may account for the observations of Coyotes in northern New York in the 1930s, as the species is not reported again from Franklin County until 1946. If this is the case – that is, that the 1930s observations of Coyotes in New York are based on introduced animals (see also Severinghaus 1974) – then the only report of a putatively naturally-colonizing Coyote in the state prior to the 1940s is a single animal from Franklin County in 1925 about 20 km south of the Québec border (Severinghaus 1974). Southern Québec, however, was not colonized by Coyotes until 1944 (Parker 1995). It is therefore possible that this animal was also an escaped or released captive.

The last documented Wolves in New York were killed in St. Lawrence and Franklin counties in the late 1890s (Fener 2001), well before Coyotes entered the region. Thus the fine-scale pattern of Coyote range expansion offers little insight on the potential link between northeastern Wolf extirpation and Coyote range expansion. The absence of Wolves from New York may, however, have increased the rate of range expansion in optimal Coyote habitat such as open areas, in turn allowing Coyotes to expand into suboptimal habitats such as heavily forested areas. Coyotes generally prefer open or agricultural lands to heavily forested habitat (Post 1975; Samson and Crête 1997; Tremblay et al 1998; Crête et al. 2001). The pattern of range expansion in and around the Adirondacks of Northern New York suggests that Coyotes first expanded in agricultural areas followed by entry into more heavily forested regions

Fener (2001) proposed that it was not the availability of open habitat per se that facilitated rapid expansion of Coyotes in New York, but rather the increase in abandoned farmlands which were in early successional stages of forest reestablishment when Coyotes entered the region. From 1920 to 1950, upwards of 2 million hectares of farmland were abandoned in New York. Farmland loss continues to the present, such that over the past century approximately 3 million hectares have been abandoned and left to regenerate naturally or been acquired and replanted by state reforestation programs (Alerich and Drake 1995; Stanton and Bills 1996). These habitats likely contain high densities of prey species for Coyotes. Thus the rapid expansion of Coyotes through New York may have been aided by entry into the region during a period when abandoned farmlands and early successional stages of forest were dominant landscape components.

Acknowledgments

This research was supported in part by funds from the Wildlife Conservation Society and the Center for Environmental Research and Conservation at Columbia University. We thank Justina Ray and Roland Kays for comments.

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Received 26 June 2003
Accepted 18 January 2005

Nesting Behavior, Ecology, Seasonal and Geographic Distribution of the Sand Wasp, *Stictiella emarginata* (Hymenoptera: Sphecidae)*

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Kurczewski, Frank E., and Hugh F. Boyle. 2005. Nesting behavior, ecology, seasonal and geographic distribution of the Sand Wasp, *Stictiella emarginata* (Hymenoptera: Sphecidae). Canadian Field-Naturalist 119(1): 6-15.

The nesting behavior and ecology of *Stictiella emarginata* are documented for the first time based on field studies made mainly at Canadian Forces Base Borden, Simcoe County, Ontario. Type of soil, natural community, temporary closure, mound leveling, orientation flight, prey transport, nest structure and dimensions, and kind and number of prey per cell are defined. Museum and field collection records support a geographic bridge from northern Michigan to the Atlantic Coast and dispel the previously held notion of a disjunct distribution for this species. A late June-July-early August flight season is inferred from observations and collections made in Ontario, New York and Michigan. The nesting behavior and ecology of *S. emarginata* and several other *Stictiella* species from the western United States, Mexico and Florida are compared.

Key Words: Sand Wasp, *Stictiella emarginata*, Noctuidae, Hesperiidae, Ontario.

The tribe Bembicini includes moderate to large-sized, stout-bodied sand wasps that are often conspicuously marked with yellow or white (Parker 1917). All species of Bembicini nest in the ground, usually in sand or gravel. The subtribe Stictiellina of the tribe Bembicini includes five genera in the Nearctic Region: *Stictiella*, *Glenostictia*, *Microstictia*, *Xerostictia* and *Steniolia* (Bohart and Gillaspy 1985). *Stictiella* contains 13 species that range collectively from Mexico into southern Canada.

Species of *Stictiella* attempt to level the mound of soil that accumulates in front of an entrance from burrow excavation. The species temporarily close the entrance with soil following burrow excavation and then make an orientation flight before going in search of prey. Species of *Stictiella* hunt and stock underground cells with adult Lepidoptera (moths, skippers, butterflies). *Stictiella* nests are one-, two- or many-celled depending on the species. The number of prey per cell is often inversely related to prey size. Most *Stictiella* species practice delayed mass provisioning; i.e., they lay an egg on the first prey placed in the cell before other prey are put inside (Evans 1966).

Stictiella emarginata (Cresson) is the most widely occurring species in the genus. It ranges from Baja California through the United States into southern Canada (Bohart and Gillaspy 1985). This species was illustrated as having a disjunct geographic distribution with separate populations extending from the Great Plains to the Pacific Ocean and from the Appalachian Mountains to the Atlantic Ocean. *Stictiella emarginata* is the only congener found in the northeastern United States and southeastern Canada.

Stictiella emarginata is virtually unknown ecologically and behaviorally. The species is seldom seen in the field or collected east of the Rocky Mountains. Nothing is known of its nesting behavior except for a single prey record, an adult *Euxoa* [Noctuidae] from the western United States (Gillaspy et al. 1962). Bradley (1908) described a sleeping aggregation of *S. emarginata* from California. Our paper documents the nesting behavior and ecology of *S. emarginata* for the first time based on observations made mainly at a single locality in southern Ontario. Our paper redefines the geographic and seasonal distribution of *S. emarginata* in the northeastern United States and southeastern Canada.

Methods

Nearly all field research on *S. emarginata* was done at Canadian Forces Base Borden, Simcoe County, Ontario. We spent 15 days in the field, sometimes from 0530 to 2000 hrs (EDT), at this site. We made field observations of wasps on 26-28 July 1996, 13-14 July 1997, 5-7, 17-19 July 1998, and 29 June-2 July 1999. We found no adult *S. emarginata* nesting at Base Borden on 11-12 August 1995, 28-30 June 1996, and 27-30 June 1997.

Field observations covering four hours were made on two females of *S. emarginata* at South Glens Falls, Saratoga County, New York, on 31 July 1993. We did not find any *S. emarginata* at this locality during three visits on 18 July 1997, 14 July 1998, and 23 July 1999. We observed one female of this species for less than an hour at the Fort Drum Military Reservation, Jefferson County, New York on 22 July 1997. We did not find any *S. emarginata* at Fort Drum during 56 hrs of observation on 2-3 August and 18 October 1996 and 3 April, 5-6, 12 July and 4 Oct 1997 (Kurczewski 1998, 1999). The trips in October were made to ascer-

*Contribution number 2005-1 of the Roosevelt Wildlife Station of the State University of New York College of Environmental Science and Forestry, Syracuse, New York.

tain that there was no fall flight of 2nd generation adults. The trip in April was made to ensure that the species did not winter and reappear in the spring in the adult stage.

Two other sites with potentially favorable habitat for *S. emarginata* were investigated but the species was not found at either locality. Seven trips were made to the Rome Sand Plains, Oneida County, New York on 27 June 1992, 28 July 1993, 13 July 1995, and 2 June, 26 July and 10, 27 September 1997 (Kurczewski 1998). Time spent observing and collecting sphecid wasps at this site on Windsor loamy fine sand totaled 35 hrs. Four trips were made to the Albany Pine Bush, Albany County, New York on 29 June 1991, 18 July 1997, 14 July 1998, and 23 July 1999. We spent 17 hours collecting and observing sphecid wasps at that locality on Colonie loamy fine sand.

We spent over 1000 hours searching unsuccessfully for *S. emarginata* in sandy and gravelly habitats in the following states and counties in the northeastern United States and southeastern Canada: INDIANA, Lake, LaPorte, Porter (21-22 June 1999); MASSACHUSETTS, Franklin (30 June 1991, 1 August 1993); MICHIGAN, Allegan, Alpena, Antrim, Arenac, Barry, Berrien, Cass, Cheboygan, Chippewa, Clare, Crawford, Emmett, Gladwin, Grand Traverse, Gratiot, Iosco, Kalamazoo, Kalkaska, Lake, Luce, Manistee, Mason, Mecosta, Menominee, Midland, Missaukee, Montcalm, Montmorency, Muskegon, Newaygo, Oakland, Oceana, Ogemaw, Osceola, Oscoda, Otsego, Ottawa, Presque Isle, Roscommon, Van Buren, Washtenaw, Wexford (15-20 June 1991; 9-12 June, 28 June-6 July, 7-10 August 1992; 10-16 June, 8-12 July, 10-12 August 1993; 12-23, 26-27 June 1994; 25-30 June 1995); NEW JERSEY, Atlantic, Burlington, Cape May, Ocean (19-21 August 1993, 14-21 June 1995, 14-16 June 1996, 21-22 June 1997, 24-25 June 1998); NEW YORK, Herkimer, Lewis, Oneida, Onondaga, Oswego, St. Lawrence, Suffolk (3-5 July 1994; 2-5 August 1996; 10 July 1997; 22, 25-27 June 1998); OHIO, Fulton, Lucas (28 June 1994; 14-20, 23-25 June 1999); ONTARIO, Elgin, Essex, Grenville, Grey, Haldimand-Norfolk Regional Municipality, Lambton, Northumberland, Prince Edward, Renfrew, Simcoe (20-27 June, 1-4, 12-25, 28 July 1996; 24-27 June, 1-2 July 1997; 15-16, 19 July 1998); PENNSYLVANIA, Erie (30 June 1994, 26 June 1999); QUEBEC, Kazabazua (31 July-1 August 1996), WISCONSIN, Adams, Bayfield, Douglas, Jackson, Juneau, Monroe (24-26 June 1994).

Females of *S. emarginata* nested mainly on warm, sunny days. Wasps excavated burrows, searched for prey, provisioned cells, and closed nests at air temperatures of 20.6-28.9°C and sand surface temperatures of 28-51°C. At Base Borden, females worked at nests from 1005 to 2005 hrs. The last female to leave her nest in the evening to join a sleeping aggregation on vegetation departed at 2006 hrs on 5 July 1998. No nesting or any other wasp activity occurred after that time. We unearthed two nests at Base Borden that evening but did not find any adult wasps in them. Collection of this species at Fort Drum was made at 1515 hrs at an air temperature of 26.7°C. At South Glens Falls, wasps provisioned nests and excavated burrows from 1321 to 1531 hrs at sand surface temperatures of 44-49°C.

All wasps from 1998 and 1999 field studies at Base Borden were color-coded by applying different colored paint to the thorax, except for two females collected as voucher specimens. All nests were flagged with numbered wooden stakes. Type of wasp activity was noted, described and quantified. Emphasis was placed on burrow excavation, temporary closure, mound leveling, orientation flight, prey transport, final closure, and evening activity. Wasps entering nests with prey were timed between consecutive provisioning trips, from entry to exit, and during temporary closure, leveling and orientation flights.

The burrow and cell(s) of each nest were excavated, examined, measured and drawn. Burrow length and design, number of cells per nest, cell depth, number of prey per cell, and position of prey in a cell and egg on a prey was recorded in the field. Prey, wasp cocoons, fly maggots and puparia were removed from the cells, placed in individual vials according to nest and cell number, put in an ice cooler, transported to a laboratory, and weighed [wet] on a Mettler balance. The aggregate prey weight of each cell was summed. The prey Lepidoptera were then pinned, code labeled, and, later, hand carried to Tim McCabe, New York State Insect Museum, for generic and specific determination. One of the two voucher specimens of *S. emarginata* was sent to Howard Evans, Colorado State University, for species confirmation. Miltogrammini cleptoparasites were compared with specimens in the State University of New York College of Environmental Science & Forestry collection determined by Margery Spofford. Wasp and prey specimens were deposited in the New York State Insect Museum, Albany.

Ecological communities and habitats were defined using Varga and Schmelefske (1992) for Canadian Forces Base Borden, Ontario, Reschke (1990) for Karner and South Glens Falls, New York, and Kurczewski (1998) for the Fort Drum Military Reservation, New York. Soil type for Base Borden was identified using the Soil Map of Simcoe County [Base Borden Area] (Soil Research Institute of Canada 1959). Soil types for Fort Drum, Karner and South Glens Falls, New York were identified from soil samples sent to Ed Stein, United States Department of Agriculture, National Resources Conservation Service.

To fill in gaps in the geographic distribution of *S. emarginata* we examined specimens and collection records from the University of Guelph, Royal Ontario Museum and Canadian National Collection for Ontario, Cornell University, American Museum of Natural History and New York State Museum for New York State, and National Museum of Natural History, Smithsonian Institution, Pennsylvania Department of Agriculture, Carnegie Museum of Natural History, and The Penn-

sylvania State University for the northeastern United States.

Weather information for Canadian Forces Base Borden, Ontario was unavailable from the base and nearby Angus weather stations as they were not operational. In order to simulate weather conditions at our research site (latitude 44°16'N, longitude 79°55'W, elevation 221 m) for May-June 1996-1999, we obtained temperatures from weather stations within 15 km of the base: Alliston Nelson (latitude 44°9'N, longitude 79°52'W, elevation 221 m), Egbert Care (latitude 44°13'N, longitude 79°46'W, elevation 252 m), and Essa Hydro (latitude 44°21'N, longitude 79°49'W, elevation 216 m), Ontario. We averaged May-June 1996-1999 temperatures from these weather stations and used these averages in a discussion of *S. emarginata* seasonal distribution.

Results

Geographic distribution

We searched 10 insect museums in Ontario and the northeastern United States and found the following unreported specimens of *S. emarginata*: ONTARIO—Regional Municipality of York, Toronto, August 1918, 1; Dufferin County, Primrose, June 1955, D. H. Pengelly, 3; Hastings County, Sydney Field Station near Foxboro, 8 July 1970, J. L. McAlpine, 1 female; NEW YORK: Albany County, Center [Karner], 28 July 1870, J. A. Lintner, 1 female. These collection records coupled with those from Pennsylvania (Parker 1929), northern Michigan (O'Brien 1989), Simcoe [Canadian Forces Base Borden] County, Ontario (Kurczewski 2000), and Jefferson [Fort Drum Military Reservation] and Saratoga [South Glens Falls] Counties, New York, when plotted on a map, reveal a contiguous, transcontinental population of *S. emarginata* in the United States and southern Canada (Figure 1).

Habitat and soils

Canadian Forces Base Borden

Two females were observed nesting at Base Borden in 1996 and 1997 in a sandy two-track running through a Red Pine [*Pinus resinosa* Aiton]—Scotch Pine [*Pinus sylvestris* L.]—graminoid savanna at the end of an airport runway (Figure 2). This two-track trail was the focal point of our 1998 and 1999 field studies. It was kept open by intermittent military vehicle use. In the early to mid-19th century droughty Tioga loamy sand (Soil Research Institute of Canada 1959),

FIGURE 1. Geographic distribution of *Stictiella emarginata* in the northeastern United States and southeastern Canada. Black circles represent collection localities as follows: MICHIGAN: Ontonagon County, Bruce Crossing; Marquette County, Huron Mountain Club (O'Brien 1989); ONTARIO: Dufferin County, Primrose; Simcoe County, Canadian Forces Base Borden; Regional Municipality of York, Toronto; Hastings County, Sydney Field Station near Foxboro; NEW YORK: Jefferson County, Fort Drum Military Reservation; Saratoga County, South Glens Falls; Albany County, Center [Karner]; PENNSYLVANIA: Cumberland County, Carlisle Junction (Parker 1929). Inset depicts geographic distribution of *S. emarginata* as illustrated by Bohart and Gillaspy (1985).

FIGURE 2. Nesting site of *Stictiella emarginata* at Canadian Forces Base Borden, Simcoe County, Ontario.

continuous pine plains, and periodic fires characterized the area. The coarse loamy sand coupled with ground and crown fires supported large Red Pine and White Pine [*Pinus strobus* L.] forests, savanna and barrens (Varga and Schmelefske 1992). Military activity on the Camp Borden Sand Plain in the 20th century maintained the savanna, barrens and sandy openings (Kurczewski 2000).

Karner

Stictiella emarginata records from 1870 exist in the form of a female specimen in the New York State Insect Museum, Albany [see above] and a male recorded in *A List of the Insects of New York with a List of the Spiders and certain other Allied Groups* (Bradley 1928). The locality of these collections is Center, an old name for Karner, a 19th century railroad stop in the heart of the Pine Bush between Albany, Albany County and Schenectady, Schenectady County, New York. Pine barrens, pine plains, and shrub savanna or pitch pine [*Pinus rigida* Miller]-scrub oak [*Quercus* spp.] barrens (Reschke 1990) still persist in preserved areas on Colonie loamy fine sand. Fires occur regularly every eight to 11 years (Benton 1976). Pitch Pine-shrub oak was a dominant plant community of the 19th century Pine Bush (Milne 1985). We found no *S. emarginata* at Karner probably because of extensive habitat destruction and expansion of alien vegetation due to fire suppression.

South Glens Falls

Two *S. emarginata* females nested in 1993 in recently bulldozed Windsor loamy sand of a construction equipment parking lot. The wasps nested near the road in a 5B slope that was too loose for heavy vehicles. This loamy sand contained many pebbles. Vegetation was similar to that at Karner, i.e., pitch pine-scrub oak barrens (Reschke 1990) with a preponderance of Pitch Pine, White Pine, shrub oaks, and Sweet Fern [*Comptonia peregrina* (L.) J. M. Coulter].

Fort Drum Military Reservation

One female was netted while flying with a noctuid moth held beneath her body in an area of Plainfield sand. The Fort Drum site contained open grassland and woodland of Pitch Pine, White Pine, Red Pine, and shrub oaks bordered by Sweet Fern (Kurczewski 1998). Original land surveys from the 1790s indicate that the area was once covered with White Pine, Pitch Pine, and oak forests with some sandy openings (Kurczewski 1997, personal observation). The site is now kept open by constant military activity. Three species of psammophilous sphecid wasps that prefer vast expanses of barren sand, *Ammophila harti* (Fernald), *Bembix pallidipicta* Smith, and *Philanthus albopilosus* Cresson, were collected at this site in addition to *S. emarginata* (Kurczewski 1998).

TABLE 1. Average temperature (°C) at Alliston Nelson, Egbert Care and Essa Hydro, Ontario weather stations, May-June 1996-1999 and first observed nesting date during those years at Canadian Forces Base Borden, Ontario.

	1996	1997	1998	1999
Alliston	15.30	17.10	17.90	17.75
Egbert	14.35	13.65	16.90	16.80
Essa	14.60	13.80	17.40	16.95
Average	**14.75**	**14.85**	**17.40**	**17.17**
1st Nesting	**26 July***	**13 July**	**5 July**	**29 June**

*First observations by us, not first nesting by wasps at site.

Flight season

Stictiella emarginata has one emergence of adults per year in the Great Lakes Region according to collection dates on museum specimens and field observations. The flight season of this species encompasses the last few days of June, July, and, rarely, early August. At Base Borden adult development, emergence and flight season was influenced by May-June temperature. Wasps nested earlier (5-7 July 1998, 29 June-2 July 1999) following warmer springs (May-June 1998, 1999 average temperature, 17.40°, 17.17° C, respectively) and later (26-28 July 1996, 13-14 July 1997) after cooler springs (May-June 1996, 1997 average temperature, 14.75°, 14.85° C, respectively) (Table 1). Similar phenology in 1998 and 1999 *S. emarginata* broods at Base Borden was probably related to similar May-June average temperatures for those years. Unsuccessful attempts to find adults of this species at Base Borden following cooler springs (28-30 June 1996, 27-30 June 1997) supports the contention that emergence is tied to May-June temperature.

Nest spacing and false starts

Four females of *S. emarginata* nested at Base Borden in 1998 in a sandy two-track, 2.5 m wide, with a grassy median, 0.9 m wide. Each track was about 0.8 m wide (Figure 2). *Stictiella emarginata* was uncommon at this site compared to other sphecid species. More than 24 *Tachysphex similis* Rohwer, eight *T. tarsatus* (Say), four *T. pechumani* Krombein, 10 *Plenoculus davisi* Fox, 12-14 *Bembix americana* (Lepeletier), and 18-20 *Philanthus politus* Say nests were scattered through the area of the two-track where *S. emarginata* nested.

Seven active nests of *S. emarginata* occupied the two tracks over three days. One section of the N track had one active nest and 10 false starts in an area 4.5 m long and 0.4 m wide. The distance between adjacent false starts ranged from 13 to 102 cm (Mean = 41.4 ± 26.37, N = 14). A section of the S track had three active nests and 26 false starts in an area 3.9 m long and 0.8 m wide. The three active nests were 25, 33 and 30 cm apart, respectively. The distance between adjacent false starts ranged from 2 to 90 cm (Mean = 27.5 ± 17.58, N = 52). Three other nests were located 4 m farther west on the S track. These nests, of different ages and possibly belonging to a single female, were only 15-18 cm apart. Four active nests at Base Borden in 1999 were spaced 1.2-7.1 m [Mean = 3.5 ± 2.52] apart. Two females nested about 1 m apart in 1993 at South Glens Falls.

Nesting behavior

Burrow excavation

Four females at Base Borden excavated burrows between 1035 and 2005 hrs in 1998. The wasps made two to eight false starts before remaining in one place and completing a burrow. One female made seven false starts in an area 0.5 m^2 before finishing a burrow. Three other wasps moved as far as 0.5-3.0 m between consecutive false starts. One female at South Glens Falls started digging a new burrow at 1531 hrs at a sand surface temperature of 44°C after nesting elsewhere from 1321 to 1530 hrs at sand surface temperatures of 45-49°C.

Females searching for a place to dig walked on the sand, tapped the surface with their antennae, and dug with the mandibles. One wasp turned completely on her side while using the mandibles. She produced an audible buzzing sound for >1 min. After the mandibles loosened the sand crust, she used the forelegs in unison to fling the loosened sand backward. Her body, especially the abdomen, moved synchronously up and down to allow the sand to pass underneath.

At Base Borden and South Glens Falls, where the soil contained loamy sand mixed with gravel, females constantly removed pebbles from their excavations. One wasp at Base Borden pulled pebbles backward with the mandibles nine times. She pulled them to the top of the sand mound in front of her entrance. The pebbles rolled down the sides of the mound and, later, became incorporated in the leveling process. The wasp then moved from the top of the mound straight into the burrow flinging sand backward with the forelegs. Females that dug nests in loamy sand without gravelly inclusions did not remove pebbles or make intermittent buzzing sounds while loosening the pebbles underground.

After removing a pebble, most wasps made a hovering flight while facing the open entrance. The female that removed nine pebbles from her excavation made a hovering flight following eight of the nine sand removals. Most hovering flights were 2-4 sec in dura-

tion but some lasted 5-10 sec. After removing sand or a pebble, some females paused and cleaned their antennae, eyes and mandibles with the forelegs.

One wasp at Base Borden removed sand from her burrow 20 times in 50 min, or an average of once every 2.5 min. A second female removed 62 sand loads in 63.5 min, or about one load per minute. A third wasp dragged backward 49 loads of sand in 50.5 min. Other females spent 69 and 60 min to excavate a burrow. At the beginning of an excavation, females were inside their burrows loosening sand with the mandibles for as long as 5-6 min before moving sand onto the surface. Toward the end of a dig, wasps often spent less than a minute for this behavior. After clearing loose sand and pebbles from the burrow, females made a temporary closure of the entrance. They appeared in the opening headfirst flinging sand backward with the forelegs in unison while tamping the fill with the end of the abdomen. Three wasps took 15, 18 and 45 sec to temporarily close their entrances, resulting in one-third to one-half of the sand mound being put back in the opening.

After closing, females leveled the mound of soil in front of the opening. They walked across the mound in various directions flinging sand backward beneath the body with the forelegs until the mound was, more or less, flattened. Wasps nesting in mixed sand and gravel then placed pebbles on the fill with the mandibles interspersed with making hovering [orientation?] flights. This sometimes involved moving debris out of the way. The hovering flights, 10-50 cm high, were 15-50 sec in duration and made 10 sec to 2.5 min apart. During mound leveling as many as 10 hovering flights were interspersed after which a wasp rested for several seconds and then flew away. Mound leveling in five females took 5.5-11.0 min (Mean = 8.2 ± 2.22).

Provisioning

Sixteen hours over three days were spent at Base Borden in 1998 and 1999 observing females bringing prey to nests. Four wasps provisioned nests from 1044 to 1820 hrs at sand surface and air temperatures of 28-36° and 22-25°C, respectively. They spent 9-77 min [Mean = 28.6 ± 22.70, N = 18] between consecutive returns to a nest with prey. Females flew into the nesting area from a distance of >10 m. Such a wasp circled slowly in flight holding the prey ventral side upward with the middle legs while producing an audible buzzing sound. She then landed on the sand mound directly in front of an entrance or as far away as 50 cm before making a second flight to the mound. Two females at South Glens Falls brought prey to their nests at 1321 and 1442 hrs at sand surface temperatures of 44°C and 49°C.

Retaining their grasp of the prey's body with the middle legs, wasps raked open the temporary closure using the forelegs in unison. Removal of a closure usually took 5-10 sec unless the area had been disturbed. Then, some females walked straight into the burrow holding the prey as described. However, most wasps released the prey ventral side upward just inside the burrow with its abdomen projecting from the entrance. Such females then turned around in the burrow, grasped the prey by its front end with the mandibles, and dragged it backward down the tunnel. Females spent about 2 min to remove the temporary closure, deposit the prey inside, *oviposit*, and remake the closure for the first prey for the cell. Not having to oviposit, a female taking subsequent prey into a nest spent only 15-45 sec [Mean = 31.6 ± 13.24, N = 18] inside and remade the closure in 6-9 sec. She then flew off immediately toward the hunting grounds making an audible buzzing sound. Some females rested on the sand before flying away. Other wasps made an orientation flight, rested on the sand, and flew away.

Final closure

After placing the full complement of prey in a cell, a wasp filled her burrow with sand and leveled the area of the entrance. One female at Base Borden appeared headfirst in her entrance 3 min after placing prey in the nest, walked onto the sand mound, and began raking sand backward into the opening with the forelegs. She repeated this behavior eight times at intervals of 15-97 sec [Mean = 65.0 ± 30.24]. This wasp made brief hovering flights, facing the entrance, following her third and fourth trips onto the mound to get sand. Near the end of the closure, the female raked sand backward from the sides as well as the top of the mound. Always facing away from the opening, she pulled several pebbles into the burrow with the mandibles and packed in sand with the end of the abdomen. She spent nearly 11 min to fill the burrow, flew a short distance away, and rested on the sand. The wasp returned to the area 1.5 min later and finished raking sand and pulling pebbles onto the filled entrance. She then flew away, 13 min after taking her last prey into the nest.

Nest structure and dimensions

Twenty-six nest entrances at Base Borden in 1998 and 1999 were mainly ovoid in shape and measured 10 × 15 mm. Below ground, the burrows were circular and 8 mm in diameter. Twenty-two burrows entered the soil obliquely at angles of 45-60B with the surface and terminated in one cell (Figure 3). One nest each at Base Borden in 1998 and 1999 was two-celled with cells 3 and 4 cm apart (Figure 3).

Base Borden burrows were significantly longer in 1998 than in 1999 [t = 3.75, df = 24, P = <0.001], ranging from 72 to 138 mm [Mean = 100.9 ± 24.35, N = 11] in 1998 and 62 to 91 mm [Mean = 71.4 ± 12.36, N = 15] in 1999. The three oldest 1998 nests had the longest burrows of 133, 138 and 135 mm. Cell depth in 1998 and 1999 at Base Borden was not significantly different, including the three oldest nests with the longest burrows [t = 0.51, df = 24, P = 0.62]. Cell depth in 1998 ranged from 43 to 73 mm [Mean = 53.3 ± 11.90, N = 11] and in 1999 from 48 to 69 mm

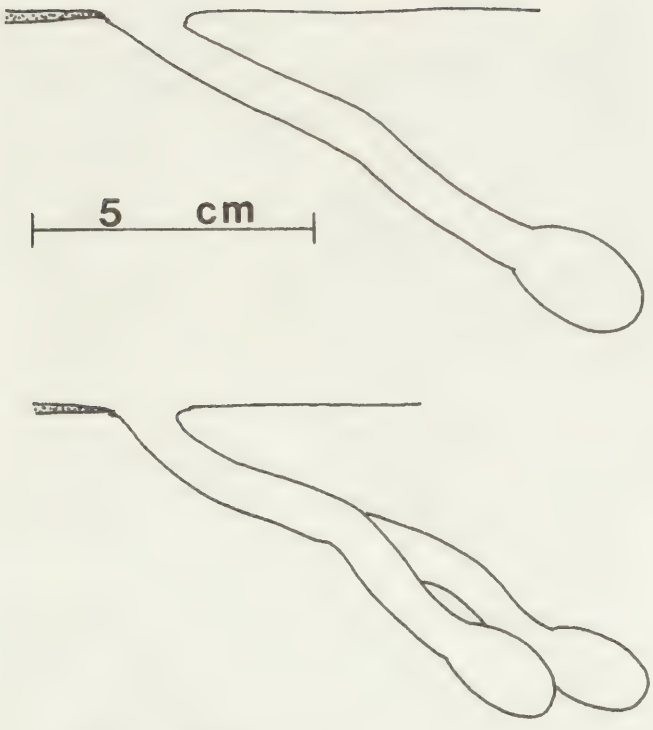

FIGURE 3. One- and two-celled nests of *Stictiella emarginata* as seen in side view. Sand mound is stippled. Scale refers to both nests.

[Mean = 51.4 ± 8.56, N = 15]. Cell size [N = 26] at Base Borden varied regardless of year: length [Range = 14-22 mm, Mean = 19.0 ± 1.71], width [Range = 13-15 mm, Mean = 14.4 ± 0.75], height [Range = 12-15 mm, Mean = 13.1 ± 0.94].

Cell contents

From five to nine prey [Mean = 6.9 ± 1.07, N = 18] were stored in fully provisioned cells at Base Borden. Individual prey weight ranged from 60.9 to 126.0 mg [Mean = 86.9 ± 17.08, N = 132]. Two wasps from Base Borden [voucher specimens] weighed 147 and 151 mg. One noctuid prey from Fort Drum weighed 93 mg. Aggregate prey weight per cell from Base Borden ranged from 456.8 to 757.9 mg [Mean = 581.6 ± 126.43, N = 18].

One cocoon from Base Borden, 69 mm deep, was 7 mm wide and 17 mm long, weighed 358.3 mg, and reared a male wasp. Two cocoons from Base Borden, 72 and 73 mm deep, were each 8 mm wide and 19 mm long, weighed 567.5 and 604.6 mg, respectively, and reared female wasps.

Of 132 prey in the cells, 78 (59.1%) were positioned head inward and ventral side upward. Fifty-four (43.5%) of the prey were placed head inward and on the side.

Females preyed on adults of seven species of Noctuidae and one species of Hesperiidae. Of 132 prey specimens, 124 (93.9%) belonged to the family Noctuidae and eight (6.1%) belonged to the family Hesperiidae (Table 2). Some prey species were associated with barren sandy and/or fire- adapted habitats. Prey individuals were probably captured on flowers or low growing herbaceous vegetation.

Egg

Stictiella emarginata eggs from four females at Base Borden in 1998 were approximately 4 mm long and 1 mm wide [N = 11]. Two recently laid eggs weighed 2.0 mg while a one day-old wasp larva weighed 2.15 mg. Eggs or 1st instar larvae were attached to the base of the prey's abdomen near its connection to the thorax or to the side of the thorax. The egg extended longitudinally along the side of the thorax toward the head. Eggs or 1st instar larvae were affixed about equally to either the left [N = 14] or right [N = 12] side of the prey.

A wasp's egg was affixed to the initial prey in the cell in eight nests at Base Borden. The position of the prey on which the wasp's egg or larva was affixed changed as additional prey items were added to the cell. In one incomplete cell with three moths, an egg was attached to the prey that was farthest in. In one cell with seven moths, a small larva was feeding in place on the fourth prey from the back end. In other cells, older larvae had moved around and were feeding on prey near the front end as these were the only prey left with nutrient value.

TABLE 2. Species of prey Lepidoptera of *Stictiella emarginata*.

Family and species of prey	Number of specimens	Source
NOCTUIDAE		
Apamea amputatrix Fitch	8	C.F.B. Borden
Apamea ophiogramma (Esper)	7	C.F.B. Borden
Calophasia lunula (Hufnagel)	25	C.F.B. Borden
Chytonix sensilis Grote	43	C.F.B. Borden
	1	Ft. Drum
	2	South Glens Falls
Euxoa scandens (Riley)	3	C.F.B. Borden
Euxoa incallida (J.B. Smith)	1	Gillaspy et al. 1962
Lacinipolia vicina (Grote)	14	C.F.B. Borden
Nedra ramosula (Guenee)	21	C.F.B. Borden
HESPERIIDAE		
Polites themistocles (Latreille)	8	C.F.B. Borden

Mortality

Five of 26 (19.2%) cells at Base Borden were afflicted with cleptoparasitic miltogrammine maggots or puparia. This included a one-celled nest in 1998 and two two-celled nests in 1998 and 1999. The single-celled nest held five paralyzed noctuids, no wasp's egg, two large maggots and two small maggots. The different sizes of the maggots indicate that the flies attacked at two different stages in the provisioning of the cell, perhaps a day apart. Both cells in the 1998 two-celled nest each held two miltogrammine puparia and six pairs of noctuid wings. The puparia in one cell were 5.5 mm long and 2 mm wide and weighed 21.9 and 21.3 mg, respectively. One cell of a two-celled 1999 nest contained seven pairs of noctuid wings and four miltogrammine puparia. The other cell held seven paralyzed noctuids, a small wasp larva weighing 2.15 mg, and four miltogrammine fly maggots. No maggots were reared to adult flies. Two puparia reared a male and female *Sphixapata vigilans* Allen [Sarcophagidae: Miltogramminae]. This fly species was observed on sand near *S. emarginata* nests and pursued provisioning wasps as they landed and entered nests.

Discussion

The geographic distribution of *S. emarginata*, as illustrated by Bohart and Gillaspy (1985), is disjunct (Figure 1). Specimens collected in the 1980s from the Upper Peninsula of Michigan brought these populations closer together (O'Brien 1989) and led us to believe that the disjunct distribution of *S. emarginata* was an artifact resulting from lack of collection records. Collection records from southern Ontario and Upstate New York field studies and museum specimens indeed bridge the gap between northern Michigan and the Middle Atlantic Region and provide evidence for a continuous, transcontinental geographic distribution for *S. emarginata*.

Stictiella emarginata has a flight period from early to mid-summer in southeastern Canada and northeastern United States. Collection dates for adults of this species from eight localities in northern Michigan, southern Ontario and Upstate New York range from 29 June [1999] to 31 July [1993]. There is one record from Toronto, Ontario labelled simply "August." Adult development, emergence and nesting at Canadian Forces Base Borden, Ontario seem to be tied to May-June temperature. Wasps nested earlier (5-7 July 1998, 29 June-2 July 1999) with warmer May-June 1998, 1999 average temperatures (17.40°, 17.17°C) and later (26-28 July 1996, 13-14 July 1997) with cooler May-June 1996, 1997 average temperatures (14.75°, 14.85°C).

Nesting information is available for six *Stictiella* taxa: *callista* Parker, *emarginata*, *evansi* Gillaspy, *formosa* (Cresson), *p. pulchella* (Cresson), and *pulchella serrata* (Handlirsch) (Table 3). Females of all species make a temporary closure of the nest. All *Stictiella* attempt to level the mound of soil in front of their entrance before flying off in search of prey. There is contradictory information about the leveling behavior of *S. formosa*. Lin *in* Gillaspy et al. (1962) observed a female "throwing...soil" behind her as she walked across the soil mound and entered the burrow. This wasp also walked across the mound in a different direction throwing soil before turning and reentering her entrance, yet Lin stated that the mound was "never leveled."

A clearly audible, high-pitched buzz accompanies an orientation flight in *Stictiella* species (Alcock and Gamboa 1975; Evans 1966; Gillaspy et al. 1962; Krombein 1964; this study). In *S. pulchella serrata* and *S. formosa* females followed potential prey as they visited low herbs, grasses, and flowers and then captured an individual with one quick strike before carrying it away in flight (Gillaspy et al. 1962). *Stictiella pulchella serrata*, *S. p. pulchella* and *S. evansi* capture moths, *S. callista* moths, skippers and butterflies, *S. formosa* skippers and butterflies, and *S. emarginata* moths and skippers (Alcock and Gamboa 1975; Evans 1966; Gillaspy et al. 1962; Krombein 1964; Parker 1917; this study)(Table 3). One female of *S. corniculata* Mickel is pinned with a noctuid moth (Bohart and Gillaspy 1985). Some cells contained only one prey species or genus [*formosa, p. pulchella*]. In other cells

TABLE 3. Nesting characteristics of species of *Stictiella*.

Characteristics	Species of *Stictiella**					
	callista	*emarginata*	*evansi*	*formosa*	*pulchella*	*serrata*
Temporary closure	+	+	+	+		+
Leveling behavior	+	+		+?	+	+
Burrow length (cm)	68	6-14	15-24	20	25-32	15-28
Cell depth (cm)	40	4-7	11-16	8-14	12-20	10-14
Number of cells/nest	1	1-2	1	5-17	1-2	1
Number of prey/cell	>1	5-9	15	7-11	19	12->21
Prey type	LHN**	HN	SG	HML	SN	CEOPSTY

**pulchella* and *serrata* are subspecies of *Stictiella pulchella*.

**Prey families of Lepidoptera are abbreviated as follows: C, Crambidae; E, Epipaschiidae; G, Gelechiidae; H, Hesperiidae; L, Lycaenidae; M, Nymphalidae; N, Noctuidae; O, Olethreutidae; P, Pyralidae; S, Pyraustidae; T, Tortricidae; Y, Phycitidae.

the species, genera and families were mixed within the known range of prey types [*formosa*, *p. pulchella*, *pulchella serrata*, *emarginata*, *evansi*].

Prey of *S. emarginata* vary in their feeding habits and are probably captured in different places. *Calophasia lunula* (Hufnagel) feeds on Butter-and-eggs [*Linaria vulgaris* Miller]. *Apamea ophiogramma* (Esper) feeds primarily on wetland grasses. *Apamea amputatrix* Fitch and *Polites themistocles* (Latreille) are also grass-feeding but may lay their eggs on non-grasses. Adults of *P. themistocles* are commonly seen on flowers along country roads. *Nedra ramosula* (Guenee) is host-specific on St. John's-wort [*Hypericum perforatum* L.]. *Lacinipolia vicina* (Grote) is a general feeder on low-growing herbaceous plants. *Chytonix sensilis* (Grote) feeds on a variety of fungi 15-20 years after a fire. *Euxoa scandens* (Riley) occurs in areas of dry, sandy soil and feeds on dicotyledons (Layberry et al. 1998; Rings and Downer 2001; T. L. McCabe 1999 personal communication).

Prey transport in *Stictiella* species is by flying, the wasp holding the prey head forward and ventral side upward with the middle or middle and hind legs. Size of prey may influence whether the hind legs assist the middle legs in prey carriage (Krombein 1964). Prey Hesperiidae of *S. formosa* were carried with the wings partly spread while prey Pyralidae of *S. pulchella serrata* were transported with the wings folded tightly against the body (Gillaspy et al. 1962; Krombein 1964). Prey Noctuidae and Hesperiidae of *S. emarginata* were carried both ways (this study). The prey is held only with the middle legs when removing the temporary closure and entering the burrow.

Final nest closure has been described only in *S. emarginata* (this study). Such behavior involves the wasp walking onto the sand mound and flinging soil backward into the open burrow. She rakes backward the loose soil using the forelegs in unison as she backs into the burrow and occasionally tamps this soil with the end of the abdomen. She levels the area of the entrance after filling the burrow flush. The entire process takes only one-fourth as long as burrow excavation.

There is much variation among *Stictiella* species in nest dimensions (Alcock and Gamboa 1975; Evans 1966; Gillaspy et al. 1962; Krombein 1964; this study) (Table 3). Although excavated in sandy soil, burrows and cells of *S. emarginata* were much shorter and shallower than in other species. The number of prey per fully provisioned cell in *Stictiella* species is highly variable (Table 3). *Stictiella emarginata* is unique in that only five to nine prey are stored per fully provisioned cell. Wasp cocoons recovered from old *S. emarginata* cells were enswathed with only six or seven pairs of noctuid wings (this study).

Although *Stictiella* species practice mass or delayed mass provisioning, there is one record for *S. pulchella serrata* that is suggestive of progressive provisioning. In that observation, a one-third grown larva was found in an incompletely provisioned cell with 21 moths. The nest had not received a final closure (Krombein 1964). There are records of delayed mass provisioning in *S. callista* and *S. evansi* in which larval wasps occupied incompletely provisioned cells (Alcock and Gamboa 1975; Evans 1966). These cells and that of *S. pulchella serrata* were provisioned for parts of at least two days.

Acknowledgments

Howard Evans (now deceased), Colorado State University, and an anonymous reviewer critically read the manuscript. Tim McCabe, New York State Museum, identified the prey Lepidoptera, furnished host plant information, and located a historical specimen of *S. emarginata*. Matthias Buck and Steve Marshall, University of Guelph, and Lubomir Masner and Jeff Skevington, Canadian National Collection, furnished southern Ontario collection records. Gary Hevel, National Museum of Natural History, Smithsonian Institution, Washington, gave us collection information from labels on specimens of *S. emarginata* from Pennsylvania. Bill Huff, Canadian Forces Base Borden, provided access to and lodging at the base and apprised us of weather conditions and potential wasp emergence.

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Received 19 June 2002
Accepted 4 March 2005

Environment and Distribution of Age 0 Fishes in River Canard, a Lowland Ontario River

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Leslie, John K., and Charles A. Timmins. 2005 Environment and distribution of age 0 fishes in River Canard, a lowland Ontario river. Canadian Field-Naturalist 119(1): 16-25.

Age 0 fishes were collected to determine occurrence, relative abundance and species composition at three sites in River Canard, Ontario in spring-autumn, 1994-1995. This small lowland river (mean annual discharge, 3.2 $m^3 s^{-1}$) has variable flow during fish spawning and early nursery periods, high suspended particulate load, and sparse rooted vegetation and other physical cover. Forty-two taxa (12 families; 24 544 specimens) collected with beach seines and a plankton net represented a wide range of reproductive strategies and a diverse taxocene. Gizzard Shad *Dorosoma cepedianum* (67% of total catch), Orangespotted Sunfish *Lepomis humilis* (8%), and Brook Silverside *Labidesthes sicculus* (6%) were the most abundant species. Environmental conditions were such that fish attained autumnal lengths comparable to species in various systems throughout the ecoregion.

Key Words: age 0 fishes, abundance, growth, turbidity, lowland river, River Canard, Ontario.

The largest number of freshwater fish species in Canada inhabit tributary streams, marshes and near shore waters of Lake St. Clair and western Lake Erie. Despite more than 200 years of human interference throughout the area, the fish community maintains a surprisingly wide spectrum of feeding and reproductive guilds. Many species considered of minor importance to local and regional economies utilise an extensive network of low gradient, silt-laden streams and drainage systems that lace the landscape (Leslie and Timmins 1990; 1998a, 1998b; Leslie et al. 1999). The eventual movement of fishes from these waters to larger systems such as the Detroit River, Lake St. Clair, and Lake Erie contributes important fauna and nutrients to the lower Great Lakes basin (Herdendorf 1987).

Because many aspects of fish reproduction and early life history have large knowledge gaps, success of fish habitat conservation, enhancement and development rests largely on synopses of general ecology and anecdotal information. Nevertheless, in Canada, the Fisheries Act (Canada Department of Fisheries and Oceans [DFO] 1984) requires protection and enhancement of spawning, nursery, and residence habitat of all species, regardless of their economic importance and despite limited commitment to their study. Moreover, a thorough knowledge of the ecosystem is necessary for proper fisheries management and to improve our ability to determine the capacity of the system for sustainable development (Haffner 1992).

This paper describes the relative contribution and seasonality of age 0 fishes at three locations in River Canard, a tributary to the Detroit River. This study intended to provide information on features of early life history of species in small tributaries, and is the first such investigation in a lowland river in the lower Great Lakes.

Study Area

River Canard (42°10'30"N; 83°05'00"W) is a base gradient (<0.4 m km^{-1}), meandering stream draining approximately 159 km^2 in the St. Clair flats, Ontario. It is about 25 km long, with a mean annual discharge of 3.2 $m^3 s^{-1}$ (Ontario Ministry of Environment and Energy [MOEE] 1994). The drainage area is predominantly heavy textured, with poorly drained soils of dark grey spleisolic, with Devonian limestone dominating the bedrock (Chapman and Putnam 1984). Water quality is strongly influenced by runoff from intensely cultivated cropland that has a legacy of pesticide, herbicide and fertiliser application. In addition, the ecosystem is subjected to detrimental effects of intense vehicular traffic on several major highways. Agricultural and municipal drainage ditches connect River Canard with Lake Erie through Big and Cedar creeks and Lake St. Clair through the Pike Creek watershed (Figure 1).

Winner and Hartt (1969) described aspects of the aquatic biota of the river, exclusive of fishes. The rotifer *Brachinus* sp., an indicator of eutrophic systems, dominated the zooplankton community. In the lower river, common submersed vegetation included pondweed *Potamogeton* sp., Coontail *Ceratophyllum demersum*, Eurasian milfoil *Myriophyllum* sp., stonewort *Chara* sp., and Eelgrass *Vallisneria americana*. Dominant emergent plants were cattail *Typha latifolia*, *T. angustifolia*, bur-reed *Sparganium* sp., bulrush *Scirpus* sp., and sedges *Carex* spp. (Winner and Hartt 1969). This community of plants prevails, with the addition

of American Lotus *Nelumbo lutea*, an exotic emergent established near the outlet to the Detroit River.

The general character of the river does not change drastically along its course; i.e., there are no pools or riffles, or vegetated backwaters. However, three sampling sites were chosen based on slight differences in physical and biological characteristics. Two sites (middle and upper reach) on the main course of the river and one (lower reach) near the confluence of a tributary to River Canard (Figure 1) were sampled for fishes. The upper reach (U: 42°07'36"N; 82°58'26"W), located about 14 km from the effluent, flows through pasture and scrubland. Stream width, typically 3 m, and depth, 0.2-0.5 m, vary according to seasonal rainfall and flood control measures. In drought conditions, the upper reach is dry. Gravel substrate predominates in the centre, with sand and clay near gently sloping banks. Emergent plants consist mainly of Broad-leaved Cattail *Typha latifolia*, Common Reed *Phragmites australis*, and Great Bulrush *Scirpus validus*. Sparse riparian vegetation consists of small shrubs; e.g., Hazelnut *Corylus americana* and Dogwood *Cornus racemosa*. Partially submersed terrestrial grasses at the stream margin provide minimal cover and associated food for fishes. Crayfish *Orconectes propinquus* are abundant at all times. At least 20 drainage ditches are connected to the river between its origin and the upper reach sampling site.

The middle site (M: 42°10'72"N; 83°02'05"W) is situated on a tributary that meanders through cropland and pasture 0.2 km east of its confluence with River Canard. Midstream depth and width were 1 m and 11 m, respectively, and the substrate consists of fine gravel and sand in the centre, with steep clay banks. No rooted aquatic plants are established, whereas trees, such as hawthorn *Crataegus* sp., Red Maple *Acer rubrum*, and Cottonwood *Populus deltoides*, form a closed canopy from mid-spring to late autumn.

In the lower reach (L: 42°10'29"N; 83°05'91"W), sampling took place 0.2 km from the Detroit River. At this location, River Canard is 230 m wide and about 1.0 m deep. Fish collections were taken at the margin of American Lotus, where grey clay is overlain with alluvium. Submersed macrophytes are sparse and scattered among debris of human origin. Broad-leaved Cattail, Giant Bulrush, and Common Reed are abundant at the shore.

Methods

In 1994, sampling took place only in the lower reach. Routine fish collections were taken weekly or twice monthly from late June to November. In 1995, collections began in mid-April and continued weekly or twice monthly until October, then once in November. Beach seines at the shore and a conical plankton net towed in open water were used to collect age 0 fishes. Most collections were made with a bagged larval fish seine (length 4 m, width 1 m, 0.3-mm Nitex mesh), hauled 10-15 m parallel to shore at maximum

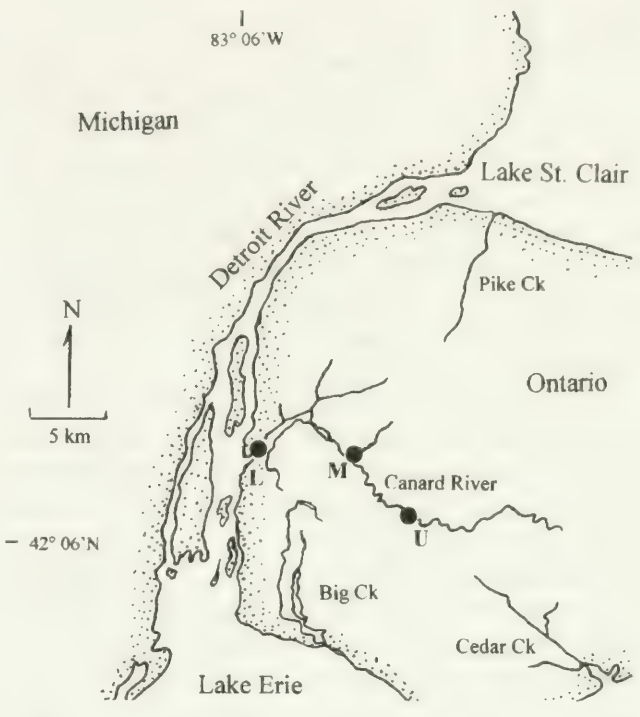

FIGURE 1. Map of study area, showing fish collection sites: L (lower reach), M (middle site), and U (upper-reach) in River Canard, Ontario in 1994-1995.

wading depth of about 1.0 m. The employment of this sampler is unique. At the end of each horizontal sweep, the seine is rapidly arced vertically to just above the surface, where contents are washed into its centre (Leslie et al. 1983). Each collection was immediately replicated at least once in the same location on each date. Specimens were immediately fixed with 5-20% formalin. Additionally, a 6-m long, 1-m wide beach seine (6 mm mesh), used to provide ancillary information (species occurrence, seasonality) on age 1^+ (juvenile and adult) fishes, swept a horizontal distance of about 15 m on 2-6 successive sampling efforts.

Twenty plankton tows were made in the lower reach to determine if species compositions in open water differed with those at the shore during usual peak occurrence of larvae in mid to late-June. Alternate tows were made upstream and downstream during the day over a constant distance of 230 m at speeds of 0.7-1.1 m/s (average, 0.9 m/s). A 0.4-m diameter, 1.5-m long conical net (0.4 mm Nitex mesh) collected fishes near the windward shore, the only habitat where depth was sufficient to perform linear hauls. The net was towed just below surface 10 m from the stern of an inflatable raft pushed by a small motor. Fish densities were expressed as number/100 m^3. Sampling took place above a substrate of gravel, sand, and alluvium where maximum depth was 1.0-1.3 m.

Jaccard's coefficient of community *Cc* (Oosting 1956) was used to compare longitudinal occurrences of fishes in the river. $Cc = 2c/a+b$, where a is the number of species at one site, b, the species in another, and c is the number of species common to both sites. In addition, a turnover index (*T*) measured assem-

blage persistence in each site. $T = (C+E)/(S_1+S_2)$, where C and E are the number of species in respective collections at sampling site S_1 and S_2 (Przybylski 1994). Persistence (P), an indicator of stochastic assemblages = 1-T. All indices range from -1 to +1; a high value of Cc indicates a large number of species shared between sites. A high value of P indicates high persistence and low fish species turnover. Common fishes were deemed species whose frequency of occurrence was >50%; uncommon occurred on 30-50% of sampling occasions, and rare fishes comprised the remainder.

All samples were processed in the laboratory within three months of collection. Specimens were placed in vials containing a 12:1 solution of 80% ethanol and glycerin, and stored in the dark at 22-25°C. Measurements of total length (TL, mm) were made on most-abundant fishes and those of special interest, such as rare taxa or recent invader. A Wild M5 dissecting microscope was used for length determinations, accurate to 0.1 mm for fish <25 mm and 0.5 mm for larger specimens. For each sampling date, 10-66 specimens (average = 26) of most-abundant species were measured. Field records included meteorological observations, water transparency (Secchi depth), water temperature, conductivity, and occasionally, pH and alkalinity. Environmental events, such as flooding or herbicide application on crops several days before sampling, may have affected the abundance of fishes. Thus, stream flow data on the sampling date and the previous two days were examined for possible concordance between flow volume and the total number of fishes found at each site.

Results

Environmental characteristics

In 1994, water temperature averaged 22°C between June and early November, conductivity averaged 434 µS/cm (range = 340-520 µS/cm), and Secchi disc 0.15 to 0.50 m (mean = 0.26 ± 0.13 m). In 1995, water temperature was maximum (29.0°C) at L in early August, 25.0°C at M in mid-August, and 29.5°C at U in mid-June (Figure 2). Conductivity was highest and most variable at M, where readings of 1120 and 1800 µS/cm were recorded in late June and September, respectively. These values coincided with some of the lowest flow volumes in the river (0.012 and 0.022 m^3/d). Conductivity was lower, and transparency higher at L than upstream, partly due to influx from the Detroit River. Eurasian milfoil first appeared in mid-May, and cattail, bulrush, Common Reed, American Lotus and Purple Loosestrife, *Lythrum salicaria,* were abundant in late July. Prolonged drought was responsible for a series of isolated pools (depth, 0.1-0.3 m) that developed at U in late June-early July. Spearman's rank correlation (r_s) analyses indicated total fish abundance and four environmental variables on sampling dates were not correlated (Table 1), nor were flow volume and abundance correlated on both days prior to sampling (r_s = -0.02 to 0.20).

Overall relative abundance and occurrence

All reproductive guilds in Canada (Balon 1975) were represented in the age 0 assemblage of 42 species, 12 families (Table 2), and total collection of 24 544 fishes. Clupeids (67%), dominated by Gizzard Shad, were the most abundant species in both 1994 and 1995; the remainder of the catch consisted mainly of centrarchids (13%), an atherinid (Brook Silverside, 6%) and 14 cyprinid species (6%). Bowfin, Spotfin Shiner, Banded Killifish, Blackside Darter, Tadpole Madtom, and Round Goby were collected only as age 1^+ fishes. Several non-indigenous species (see Table 2 for scientific names), classified "Vulnerable" (Campbell 2001), were also found.

Twelve common species were recorded, although only three contributed >5% to total catch (Table 2). Common Carp and Orangespotted Sunfish were the only common fishes among seven introduced species, including Alewife, Bigmouth Buffalo, Goldfish, White Perch and Round Goby. Maximum fish abundance occurred at all sites on the same date (23 June) and in similar environmental conditions in 1994 and 1995 (Figure 3): low, declining flow (0.01-0.05 m^3/d), low transparency, high conductivity, medium-high water temperature (23.5 to 29.5°C), and in L, surface emergence of American Lotus.

Gizzard Shad was the most abundant age 0 fish at L and M, and centrarchids at U, where Orangespotted Sunfish alone represented 68.3% of total catch at that site. Bluntnose Minnow, Orangespotted Sunfish, and Quillback were the only species more abundant in U than downstream. White Suckers were exclusive to M, whereas Goldfish were caught only at U (Table 2).

Frequency of occurrence of all taxa averaged 35% in L, compared with 28% and 22% in M and U, respectively. Most species, including several listed as "vulnerable" in Canada: Bigmouth Buffalo, Pugnose Shiner, Pugnose Minnow, Central Stoneroller, and Longear Sunfish, were caught sporadically and in low number. Between-site species turnover of age 0 fishes differed according to sampling dates, ranging from 0.9 in early August at L and M, to 1.0 (complete lack of persistence) at L and U in early June.

Overall species richness increased by a factor of 2.2 from upper to lower reach. Assemblages of age 0 fishes were similar taxonomically at all sites only in the first few weeks in June (Cc = 0.33 to 0.46). Generally, lowest persistence, or highest turnover, also took place in mid-June. Highest coefficient of community (0.5) was recorded in mid-June, when many taxa intermingled at all sites. The middle site and U usually shared fewer species than M and L. Fish co-occurrence, both between L and M and L and U, were minimum in early August (Cc = 0.13 and 0.08, respectively), and M and U in early July (0.07).

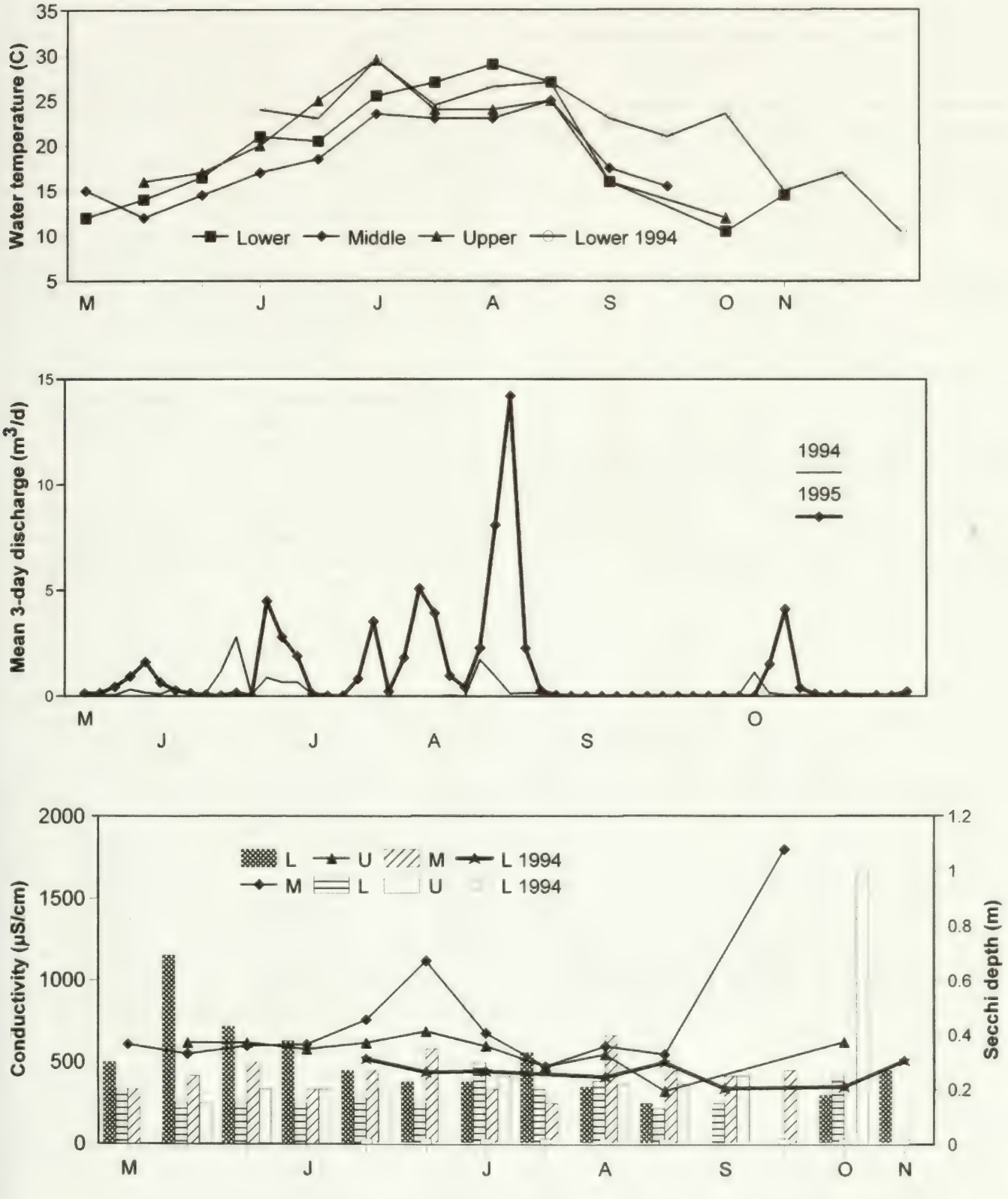

FIGURE 2. Environmental variables for River Canard: water temperature at three sites (upper), mean 3-day discharge (middle), and conductivity and Secchi depth (transparency) (lower graph).

Fish Seasonality

Upper reach

Abundance and frequency of occurrence of age 0 species (17 taxa) were consistently low (Figure 3). A single Central Mudminnow (18 mm TL) was the only age 0 fish found in late May. Quillback (15.9 ± 0.8 mm; N = 42) next appeared (early June), but was not recorded after late June. Johnny Darters (9-11 mm), which first appeared in early June, contributed 7.4% to the total catch (1839 fishes). Small numbers of recently hatched Common Carp (5-7 mm) were also caught in early June, but were not found after mid-July. No adult Gizzard Shad were caught on any date. However, Shad larvae were found sporadically until early Sep-

TABLE 1. Spearman's rank correlation coefficients for overall fish abundance relative to environmental variables in River Canard. Upper row denotes 1994 values. Number of measurements in parentheses.

Variable	Lower reach	Middle site	Upper reach
Conductivity	0.539 (12)		
	0.154 (9)	0.212 (10)	0.381 (8)
Secchi depth	0.150 (10)		
	0.142 (9)	-0.433 (10)	0.226 (8)
Temperature	0.523 (12)		
	-0.233 (9)	0.422 (10)	-0.536 (8)
Flow volume	-0.119 (12)		
	-0.300 (9)	-0.139 (10)	-0.429 (9)

tember, when the largest specimen (94 mm) was collected. As flow volume decreased to 0.01 m^3/d in late June, an isolated pool (~350 m^2) developed at the sampling site. Eight species and 81% of the total collection were caught in this pool on 23 June. Orangespotted Sunfish was the sole recurring adult fish.

Middle site

Fishes represented 18 species and 7 reproductive guilds at the middle site. Non-guarding phytophils (Common Carp, Bigmouth Buffalo) and guarding nest-spawners, such as psammophils Bluntnose Minnows, Black Crappie, numerically dominated the assemblage. Highest catch and number of species were observed in late June (Figure 3). Logperch were first caught in mid-May and Gizzard Shad, Yellow Perch, White Sucker, and Quillback in early June. Common Carp (9.4 ± 2.6 mm; N = 23), Bluegill, and Emerald Shiner next appeared in late June. Gizzard Shad, which represented 78.5% of the total collection (4744 fishes), was the only highly persistent species (Table 3). Although various age 0 and 1+ fishes co-occurred in early spring and autumn, they were usually temporally separate during the early summer nursery period. Emerald Shiner was the only adult fish caught repeatedly.

Lower reach

Although sampling in 1994 began in late June, 12 taxa were found that were not caught in 1995, when collections began in April. However, these fishes con-

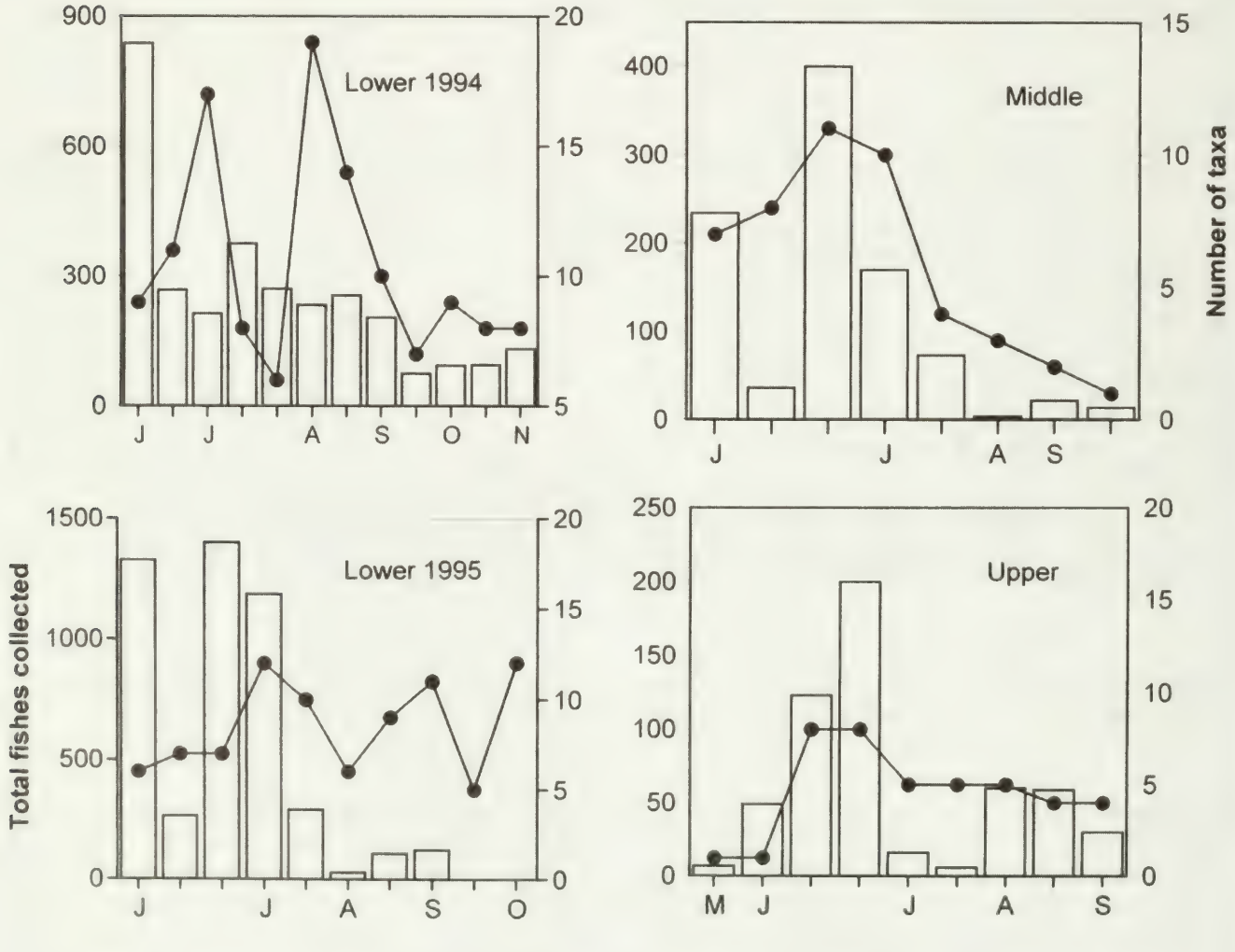

FIGURE 3. Seasonal total catch (bar) and number (line) of age 0 fishes found in River Canard, 1994-1995.

TABLE 2. Age 0 fish (0) species in River Canard lower (L), middle (M), and upper (U) sites, 1994-1995. 1+ indicates occurrence of juveniles >1 year old, or adults. f_o= relative overall occurrence: C common, U uncommon, R rare. Guild = reproductive classification (Balon 1975): Ph phytophil, Lp lithopelagophil, Pl phytolithophil, Ps psammophil, Pe pelagophil, Sp speleophil, P polyphil. Total catch 24544. TL (mm) indicates smallest *measured* specimen of each species. Species status: N Native, I introduced, V "vulnerable". Species names follow Mandrak and Crossman (1992).

Species	Common name	Status	L	M	U	Guild	f_o	Catch (%)	TL
Lepisosteus osseus	Longnose Gar	N	0		0	Ph	R		80
Amia calva	Bowfin	N	1+			Ph	R		
Dorosoma cepedianum	Gizzard Shad	N	0, 1+	0	0	Lp	C	66.6	4
Alosa pseudoharengus	Alewife	I	0			Pl	R		34
Esox lucius	Northern Pike	N	0, 1+	1+	0, 1+	Ph	R		102
Umbra limi	Central Mudminnow	N			0	Ph	R		18
Moxostoma macrolepidotum	Shorthead Redhorse	N	0			Li	R		74
Moxostoma sp.	Redhorse sp.	N	0	0		Li	R		
Catostomus commersoni	White Sucker	N		0, 1+		Li	R		18
Ictiobus cyprinellus	Bigmouth Buffalo	I, V	0	0	0	Ph	U		60
Carpiodes cyprinus	Quillback	N	0, 1+	0	0, 1+	Ps	C	1.1	6
Notropis atherinoides	Emerald Shiner	N	0, 1+	0, 1+	1+	Pe	C	2.5	6
Notropis hudsonius	Spottail Shiner	N	0, 1+	0, 1+	0, 1+	Ps	C	0.5	11
Notropis volucellus	Mimic Shiner	N	0, 1+	0, 1+		Pl	R		23
Notropis stramineus	Sand Shiner	N	0			Ps	R		23
Luxilus cornutus	Common Shiner	N	0, 1+		1+	Li	R		35
Notropis anogenus	Pugnose Shiner	N, V	0, 1+			Li	R		30
Opsopoeodus emiliae	Pugnose Minnow	N, V	0, 1+			Ph	R		22
Notemigonus crysoleucas	Golden Shiner	N	0		1+	Ph	R		26
Cyprinus carpio	Common Carp	I	0, 1+	0, 1+	0, 1+	Ph	C	1.0	5
Carassius auratus	Goldfish	I	1+		0	Ph	R		24
Cyprinella spiloptera	Spotfin Shiner	N	1+			Pl	C		26
Campostoma anomalum	Central Stoneroller	N, V			0	Li	R		
Pimephales notatus	Bluntnose Minnow	N	0, 1+	0, 1+	0, 1+	Sp	C	1.3	8
Pimephales promelas	Fathead Minnow	N	0, 1+	0, 1+	0, 1+	Ps	R		21
Ameiurus nebulosus	Brown Bullhead	N	0, 1+		1+	Sp	R		42
Ictalurus punctatus	Channel Catfish	N	0, 1+			Sp	R		53
Noturus gyrinus	Tadpole Madtom	N			1+	Sp	R		
Fundulus diaphanus	Banded Killifish	N	1+			Ph	R		47
Morone chrysops	White Bass	N	0			Pl	R		37
Morone americana	White Perch	I	0			Pl	R		56
Lepomis gibbosus	Pumpkinseed	N	0, 1+			P	R		
Lepomis megalotis	Longear Sunfish	N	0			Li	R		28
Lepomis cyanellus	Green Sunfish	N	0, 1+		0, 1+	Li	R		40
Lepomis humilis	Orangespotted Sunfish	I, V	0, 1+	0, 1+	0, 1+	Li	C	8.4	5
Lepomis macrochirus	Bluegill	N	0, 1+	0, 1+	0, 1+	Li	C	3.5	3
Ambloplites rupestris	Rock Bass	N	0			Li	R		38
Micropterus salmoides	Largemouth Bass	N	0, 1+			Ph	R		17
Micropterus dolomieu	Smallmouth Bass	N	0, 1+			Li	R		
Pomoxis nigromaculatus	Black Crappie	N	0, 1+	0, 1+	0	Ph	C	1.1	7
Pomoxis annularis	White Crappie	N	0, 1+	1+	1+	Ph	R		48
Perca flavescens	Yellow Perch	N	0, 1+	0		Pl	R		11
Etheostoma nigrum	Johnny Darter	N	0, 1+	0	0, 1+	Sp	C	1.1	5
Percina caprodes	Logperch	N	0, 1+	0, 1+		Ps	R		14
Percina maculata	Blackside Darter	N	1+		1+	Li	R		
Labidesthes sicculus	Brook Silverside	N	0, 1+	0		Pl	C	6.3	5
Aplodinotus grunniens	Freshwater Drum	N	0, 1+			Pe	R		3
Neogobius melanostomus	Round Goby	I	1+			Sp	R		

tributed just 3% to the overall catch. Conversely, Logperch, Smallmouth Bass, and Longnose Gar, found in 1995 were not caught in 1994; these fishes were caught in small number, usually on a single date. Gizzard Shad (25.4%), Brook Silverside (21.9%), Orangespotted Sunfish (19.2%), and Bluegill (13.9% of total catch) were most abundant of 36 species and 3055 specimens collected in 1994. Frequency of occurrence of these four taxa was also highest (f_o = 0.8-1.0) throughout the sampling period. Orangespotted Sunfish and Spottail Shiners were the only adult fishes collected consistently.

TABLE 3. Percent contribution, seasonality, and frequency of occurrence (parentheses) of dominant fishes at three collection sites in River Canard, 1994-1995.

Species	Lower			Mid			Upper	
	1994		1995					
Gizzard Shad	25.4	June-November (1.0)	80.7	June-October (0.9)	78.5	June-September (0.9)	6.2	June, August, September (0.3)
Emerald Shiner	5.4	June-November (0.2)	0.6	June-August (0.4)	8.1	June-July (0.3)		
Common Carp	0.2	June-July (0.3)	0.5	June-August (0.4)	2.9	June-July (0.4)		June (0.2)
Bluntnose Minnow	1.2	June-August (0.6)	0.2	June-July, September (0.5)		June (0.1)	13.7	June-August (0.6)
Orangespotted Sunfish	19.2	June-November (0.9)	0.6	June-August (0.6)	1.2	June-July (0.2)	68.3	June-September (0.6)
Bluegill	13.9	June-November (0.8)	3.1	June-September (0.8)	2.9	June-July (0.4)	1.8	June, September (0.2)
Brook Silverside	21.9	June-November (0.9)	10.1	June-September (0.6)		July (0.1)		
Total catch	2671		8452		1089		1532	

TABLE 4. Comparitive growth in length of eight species of age-0 fishes in the Great Lakes basin.

Species			Mid-month TL (mm)		
	System	Year	August	September	Reference
Gizzard Shad	Lotic	1994	62.2 (42)	80.2 (66)	Present study
		1995	69.7 (26)	77.8 (19)	
	Lotic	1994	48.5 (23)	72.3 (27)	Leslie et al. 1999
	Lentic	1994	45.7 (15)	58.2 (26)	Leslie and Timmins 1998b
	Lentic	1990	51.9 (20)	74.0 (18)	Leslie and Timmins 1998b
	Lacustrine	1983	32.5 (82)		Leslie and Timmins 1993
Brook Silverside	Lotic	1994	42.6 (25)		Present study
	Lotic	1994	44.6 (24)		Leslie et al. 1999
	Lentic	1994	46.0 (23)		Leslie and Timmins 1998b
	Lacustrine	1983	43.0 (59)		Leslie and Timmins 1993
Emerald Shiner	Lotic	1994	33.9 (35)	43.5 (14)	Present study
	Lotic	1994	34.7 (43)	41.5 (26)	Leslie et al. 1999
	Lotic	1994	44.9 (39)	48.2 (32)	Leslie et al. 1999
	Lacustrine	1994		42.4 (21)	Leslie and Timmins 1998c
Bluntnose Minnow	Lotic	1994	26.0 (15)		Present study
		1995	29.5 (24)		
	Lotic	1994	45.3 (8)	50.2 (20)	Leslie et al. 1999
	Lacustrine	1977	36.4 (72)	51.3 (79)	Keast and Eadie 1984
	Lacustrine	1998		29.7 (55)	Leslie and Timmins 2002
Orangespotted Sunfish	Lotic	1994		38.1 (23)	Present study
		1995		34.6 (15)	
	Lentic	1990		36.5 (22)	Leslie and Timmins 1998b
Bluegill	Lotic	1994	30.6 (37)	36.9 (26)	Present study
		1995	31.0 (15)	34.4 (48)	
	Lotic	1994		33.3 (67)	Leslie et al. 1999
	Lacustrine	1977	16.4 (56)	26.7 (35)	Keast and Eadie 1984
	Lentic	1990		28.7 (19)	Leslie and Timmins 1998b
Black Crappie	Lotic	1994	56.7 (26)	59.9 (15)	Present study
		1995		62.2 (29)	
	Lotic	1994	55.5 (12)	61.2 (17)	Leslie et al. 1999
Largemouth Bass	Lotic	1994		91.9 (10)	Present study
		1995		72.6 (10)	
	Lacustrine	1977		48.6 (89)	Keast and Eadie 1984

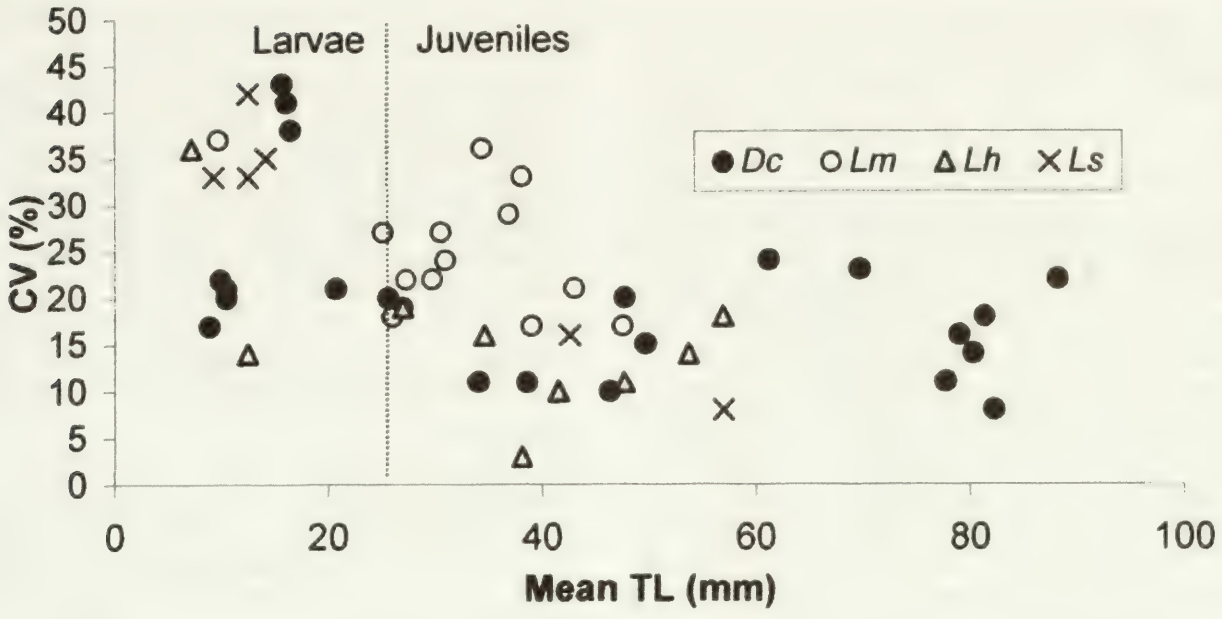

FIGURE 4. Coefficient of variation in mean total lengths of Gizzard Shad (*Dc*), Bluegill (*Lm*), Orangespotted Sunfish (*Lh*), and Brook Silverside (*Ls*) in River Canard, Ontario. Vertical line delineates larvae (<25mm) and age 0 juveniles.

Total catch in 1995 (8771 fishes, 26 species) was dominated by Gizzard Shad (80.7%), Brook Silverside (10.1%) and Bluegill (3.1%). No fish larvae were found in April or May. Largest catches of Gizzard Shad (4-5 mm), Orangespotted Sunfish and Bluegill were made in late June. Spottail Shiner, Bluegill, Black Crappie, Brook Silverside, Bluntnose Minnow, and Largemouth Bass were considered "residents" based on high persistence. As in 1994, adult Orangespotted Sunfish and Spottail Shiner were collected on most dates.

Plankton net hauls in open water collected 5280 age 0 fishes (10 species) in mid-June, 1995. None of these species was unique to the assemblage collected with beach seines. However, because Freshwater Drum spawn in open water where semi-buoyant eggs drift with currents, the plankton net collected more eggs and free embryos (3.7 ± 0.4 mm; N = 13) than did the beach seine. Total catch was dominated by Gizzard Shad (97.3%), Common Carp (1.0%) and Freshwater Drum (0.6%). Mean fish density varied widely among hauls and dates. For example, mean densities ranged from 4201 to 6390/100 m^3 and 1199 to 2419/100 m^3 on 11 June and 12 June, respectively.

Growth of most-abundant fishes

Lengths near the end of first year growth differed according to species. Bluntnose Minnow and Brook Silverside were the only fishes that nearly attained adult length in late summer. Gizzard Shad, Largemouth Bass, and Black Crappie are among the largest fishes in the assemblage (Table 4). These species achieved 12 to 25 times their length at hatch, whereas small-bodied fishes (e.g., cyprinids, Brook Silverside) increased 6 to 8-fold hatch size. Coefficient of variation (CV) in mean total length of four most-abundant species was highest in larvae (<25 mm) and tended to decrease with size (Figure 4). In general, highest variability in species' lengths coincided with overall peak abundance in mid-June to mid-July.

Discussion

The assemblage of age 0 fishes (42 taxa) may be considered a cyprinid-centrarchid-clupeid-atherinid complex numerically representing 91% of the catch (Table 2) and 63% of a taxocene strongly dominated by a planktivore, Gizzard Shad. Lithophils (non-guarding and guarding) and phytophils otherwise predominate in constant turbid water and shoreline with limited diversification. Larvae of these guilds are initially photophobic (Mann 1996) and in this respect, perhaps tolerant of turbid conditions. However, the presence of most species in River Canard belies spawning requirements for gravel, macrophytes, and clear water. Orangespotted Sunfish selects shallow, silt-laden water (Noltie and Beletz 1984) and is an appropriate indicator species, contrary to Bluegill, which usually chooses vegetated shallows in clear water (Trautman 1981).

Similarly, Emerald Shiner, a pelagophil, was common and abundant at the middle site and in the lower reach. It was also found, albeit in low numbers, in adjacent watersheds, shore areas, and streams in south-east Lake St. Clair and western Lake Erie (Noltie and Beletz 1984; Leslie and Timmins 1998a,b,c; Leslie et al. 1999). Undoubtedly, this is a plastic species with considerable ecological amplitude, as is the Bluntnose Minnow. Brook Silverside, another common taxon, usually spawns on emergent or floating leaf plants, hence its absence in the upper reach and presence in the lower reach. The assemblage in the lower reach represented many ecological guilds dominated by persistent fishes, such as Gizzard Shad, Brook Silverside, Emerald Shin-

er, Orangespotted Sunfish, and Bluegill. Gizzard Shad spawned in the upper reach and undoubtedly further upstream in connecting minor drainage systems, where larvae are found in vast number (Leslie and Timmins 1990).

Most fishes expanded their ecological limits with growth and development. Species turnover was typically high and relatively few taxa occurred simultaneously at the three sites. These findings concur with those in similar studies in adjacent watersheds of the St. Clair and western Lake Erie flatlands (Leslie and Timmins 1990, 1998a; Leslie et al. 1999). Commonly, species richness and abundance are highly correlated with macrophyte diversity and shallow marginal habitat that provides refuge against predators (Eadie and Keast 1984; Petering and Johnson 1991; Copp and Mann 1993; Mann 1996; Duncan et al. 2001). Sinuous and sluggish, River Canard is devoid of vegetated backwaters that enhance diversity, spawning and nursery habitats, and food availability (Oberdorff et al. 1993). Nevertheless, Pugnose Minnow, Pugnose Shiner, and Central Stoneroller, sensitive to turbid waters, tolerated adverse conditions, at least temporarily.

Environmental variables and species numbers were not related with seasonal abundance (Table 1; Figure 3). Number and abundance of age 0 fishes in the lower reach were likely augmented by continuous larval drift, individuals purged from upstream during spates, and migrants from connecting drainage ditches and the Detroit River. Although River Canard appears to be a harsh environment for fishes during early ontogeny, large numbers of taxa have adapted to, if not thrived, in this highly perturbed system. Abiotic and biotic factors influence rate of growth during early development, and hence, recruitment. Total length attained by recruits near end of summer may well reflect these factors, providing sampling does not seriously bias size distributions of any given species (Bayley and Dowling 1993; Leslie and Timmins 1994).

With few exceptions, dominants were much the same length as those recorded elsewhere in the ecoregion (Table 4). For example, Gizzard Shad and Emerald Shiner reached autumnal lengths comparable to those in turbid streams and bays but less than in waters of higher quality, transparency and productivity, such as the Detroit River (Leslie et al. 1999). Orangespotted Sunfish were slightly longer in River Canard than reported for specimens in lowland Ohio streams (Trautman 1981), whereas Bluntnose Minnows were smaller than counterparts in the St. Clair region. Similarly, Bluegill and Brook Silverside attained lengths similar to those of species elsewhere in the lower Great Lakes basin (Trautman 1981; Leslie and Timmins 1990; 1998a,b; Leslie et al. 1999). Size range relative to mean total length of cyprinids and other small species was usually much lower for age 0 juveniles than for larvae, as was overall coefficient of variation in length. Sampling bias, predation, and natural mortality of smallest fish may effect a reduction in variability in length as growth reaches a plateau.

The diverse age 0 fish taxocene in River Canard is represented by all reproductive guilds in Canada. Yet, according to descriptions in Scott and Crossman (1973) and Trautman (1981), fewer than 25% of species listed in Table 2 normally utilise environmental conditions that prevail in the river. Apparently, assignment of certain species to a specific reproductive or ecological guild requires revision for Great Lakes as well as European freshwater fishes (Mann 1996). Perhaps these realities reflect our limited knowledge of fish ecology in lowland streams.

Acknowledgments

We thank Susan Saunders of Water Surveys of Canada, Burlington, for flow data for River Canard, R.E. Dermott for assistance in the field, and several anonymous reviewers.

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Received 20 May 2003
Accepted 22 November 2004

Charophytes of Insular Newfoundland II: *Chara evoluta* and *Chara canescens*

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Mann, Henry, and E. M. V. Nambudiri. 2005. Charophytes of Insular Newfoundland II: *Chara evoluta* and *Chara canescens*. Canadian Field-Naturalist 119(1): 26-37.

The rare Newfoundland disjuncts *Chara evoluta* and *Chara canescens* are compared morphologically, ecologically, and geographically. Although very similar morphologically, they can readily be distinguished by their monoecious/dioecious nature, cortical cell features and coronula size. Ecological differences are more subtle and difficult to quantify. In Newfoundland the two species are restricted to coastal saline lagoons in the southwest region of the Island, with *C. evoluta* exhibiting an association with *Chara aspera*. The flora and fauna of these unique habitats are poorly documented even though it is known that they are associated with other rare species including the Piping Plover and the Banded Killifish. Consideration of some degree of protection as special habitats within the provincial ecological reserve strategy is suggested. An updated key to all species of charophytes known to inhabit Newfoundland and Labrador is included, and a brief overview of their ecological distributions is provided.

Key Words: charophytes, Characeae, *Chara evoluta*, *Chara canescens*, *Chara aspera*, coastal lagoons, Newfoundland.

The first survey of the charophytes of Newfoundland (Mann 1989) described ten taxa, three of *Nitella* and seven of *Chara*. Distribution maps and a key were provided. Subsequently *Tolypella glomerata* (Desv.) Leonh. was reported from the Great Northern Peninsula (Mann 1994a). In 1995 *Chara evoluta* T. F. Allen was discovered as well as a second site for *Chara canescens* Desv. & Lois. in Lois. and these were added to the list for Insular Newfoundland (Mann 1998, 2000*; Mann et al. 1999). A search of saline coastal lagoons and estuaries on the southwest coast of Newfoundland identified several more sites for *C. evoluta*, but no more for *C. canescens*. Information, including morphological, taxonomic, geographical and ecological, has never been published for this disjunct population of *C. evoluta* in Newfoundland. Because the two species are so similar morphologically and ecologically, and because both *C. evoluta* and *C. canescens* are considered rare species in Newfoundland, eastern Canada, and *C. evoluta* in eastern North America, the two will be treated together in a comparative way. They also need to be distinguished and reported as separate taxa, a problem which arose since the publication of Wood's (1965) monograph where they were merged under *C. canescens*, a concept which is no longer defensible (Proctor 1980). Due to the disjunct nature of Newfoundland populations it is important to determine whether local populations exhibit any features differing from those elsewhere in North America. This is also necessary for future studies comparing similar Asian taxa. T. F. Allen's (1882) original description of *C. evoluta* and those of Robinson (1906), and Wood's chosen lectotype in Wood and Imahori (1964) are the basic sources for this species supplemented with North American specimens on loan from the New York Botanical Garden (NY). It may be assumed that features not here described or elaborated upon are consistent with those in the above reports.

A new key is prepared incorporating species not included in the original work (Mann 1989) and based on current concepts of charophyte taxonomy and nomenclature.

Material of *C. evoluta* and *C. canescens* is housed in the Sir Wilfred Grenfell College Herbarium (SWGC) as liquid preserved specimens and herbarium sheets. Voucher specimens have been deposited with the Newfoundland Museum (NFM), the Canadian Museum of Nature, Ottawa (CANA), and the Phycological Herbarium of Memorial University (NFLD), (*C. evoluta*, Mann numbers 228, 282; *C. canescens*, Mann number 229). Herbarium acronyms are as in Holmgren et al. (1990), except for the Sir Wilfred Grenfell College (SWGC) which is not yet listed. Vascular plant nomenclature follows Crow and Helquist (2000), that of invertebrate groups, Barnes (1994), and fishes, Scott and Crossman (1973). Methods for gametangial measurements and illustrations are consistent with those described in Mann (1994b). Spore preparation for the SEM followed the method of John and Moore (1987).

Study Area and Habitat

The study area where *C. evoluta* and *C. canescens* are located includes south-western Newfoundland extending from Port aux Basques in the south and northward to the Port au Port Peninsula (Figure 1). All sites are coastal saline lagoons or salt ponds, sometimes designated as "barachois" locally. The southernmost cluster of five lagoons can be located on Canadian Topographic Map 11-0/11, "Port aux Basques". Codroy Estuary Pond has UTM map co-ordinates of 314E

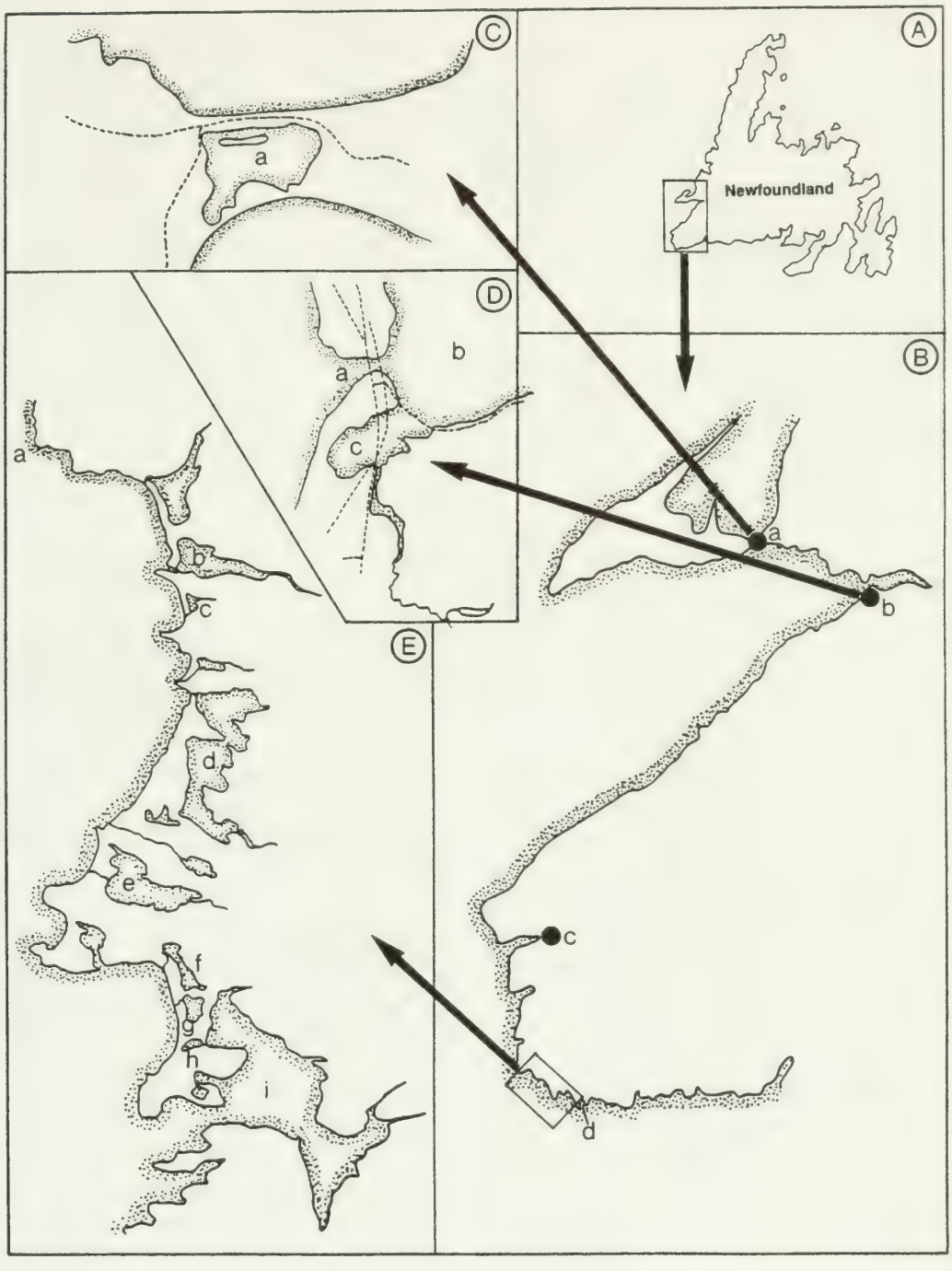

FIGURE 1. Location of collection sites in Insular Newfoundland.

A. Study area of southwestern Newfoundland inset.
B. Coastal Newfoundland from Port aux Basques to the Port au Port Peninsula: (a) Gravels Pond, (b) St. George's Pond, (c) Codroy Estuary Pond, (d) Port aux Basques.
C. Isthmus of the Port au Port Peninsula: (a) Gravels Pond. Dashed lines indicate roads.
D. St. George's Bay: (a) Main Gut, (b) Estuary, (c) St. George's Pond. Dashed lines indicate roads and a railway embankment.
E. Coastal Newfoundland from Cape Ray to Grand Bay: (a) Cape Ray, (b) Little Barachois, (c) Osmond Pond, (d) Big Barachois, e. Rocky Barachois, (f) Salt Water Pond, (g) Second Pond, (h) First Pond, (i) Grand Bay.

and 018N on map 11-0/14, "Codroy". The more northern Gravels Pond is indicated on map 12-B/10, "Stephenville", and the St. George's Lagoon on map 12-B/8, "Main Gut".

The southern five lagoons from Grand Bay to Cape Ray Cove are formed behind sandy beach and dune deposits. All have breachways to the ocean, but the channels are not active during most of the year and no seawater exchange is apparent normally, except for First Pond where exchange may occur more often. Outflow occurs during spring runoff, but there is evidence that some saltwater influx occurs to maintain their brackish nature. All of these ponds drain freshwater from inland peatlands and heath barrens. The small Codroy Estuary Pond is in the floodplain of the estuary, but is isolated from estuarine water except

during spring flooding. St. George's Lagoon is separated from the ocean by a sand barrier of 100 meters in width. Originally connected to the estuary, it is now separated by highway and railway embankments, but still receives some influx via culverts where saline estuarine water intermixes with the freshwaters of Little River draining the interior peatlands. Gravels Pond in the narrow isthmus of the Port au Port Peninsula is separated on either side from the ocean by a narrow cobble/shingle barrier.

Coastal lagoons in this study are non-tidal, but only semi-isolated systems receiving some periodic seawater influx. As such, the salinity of their waters varies with the seasons and is also subject to rapid fluctuations because of heavy rains, storm surges, salt spray, and perhaps some percolation through the barrier as possibly occurs in Gravels Pond. Because of irregular sporadic episodes of varying intensity they are habitats extremely difficult to characterize and compare other than through intensive long-term monitoring (Barnes 1980). In 1995 Gravels Pond ranged in specific conductance (μmhos = μ siemens) from 10 000 in July, 15 200 in August, to 22 200 in September. According to the salinity scale of Cowardin et al. (1979), Gravels Pond is in the brackish mesohaline category. First Pond, Second Pond, and Saltwater Pond exhibited single readings of 26 400, 18 000, and 27 000 μmhos respectively in July 1999, also categorizing them as mesohaline. St. George's Lagoon had the lowest readings ranging from 400 to 7500 μmhos characterizing it as fresh to oligohaline. Internally, lagoons are often not uniform with regard to salinity, possessing zones depending on the location and volume of freshwater entry as well as periodic marine influx (Barnes 1980).

The Newfoundland lagoons which are separated from the ocean by a sandy barrier have extensive shallow sandy-bottomed areas on their seaward sides due to windblown sand drift from the outer beaches and gradually deepen to several meters on their landward sides. This produces an unstable sandy shifting substrate subject to wave action where vascular vegetation is sparse or absent, but to some extent successfully colonized by charophytes. On these shallow flats, charophytes form open scattered stands where individual plants tend to be tiny, only a few centimeters, and deeply embedded in the sand substrate. In deeper areas or sheltered locations with more stable substrates, denser beds of larger charophytes and beds of vasculars occur.

Aquatic vasculars largely consist of broad-ranging and saline tolerant species including Sago Pondweed (*Potamogeton pectinatus* L. = *Stuckenia pectinata* (L.) Borner), Widgeon-grass (*Ruppia maritima* L.), and Horned Pondweed (*Zannichellia palustris* L.). In zones of lower salinity Clasping-leaved Pondweed (*Potamogeton perfoliatus* L.) and Mare's-tail (*Hippuris vulgaris* L.) are occasionally found. Eelgrass (*Zostera marina* L.) is absent from these charophyte dominated lagoons, but is common and forms extensive stands in tidal lagoons which also occur in the area (e.g., Big Barachois, Figure 1). Charophytes have not been located in the tidal lagoons, but potentially may occur near freshwater inlets.

Although the aquatic fauna was not systematically sampled, the following organisms were commonly noted: amphipods, water boatman, snails, opossum shrimps, aquatic beatles, and a variety of insect larvae forms. Two fish species were encountered. The Theespine Stickleback (*Gasterosteus aculeatus* L.) is common in all lagoons amongst the charophyes. As well, in First Pond the Banded Killifish (*Fundulus diaphanus* Leseur) was commonly in the charophyte beds.

Species diversity decreases with increased salinity in inland waters (Cole 1994), but in addition, coastal lagoons often present a widely fluctuating ionic environment which cannot be tolerated by most marine organisms as well as most freshwater derived inland forms. Biodiversity, therefore, tends to be low and lagoons are inhabited by organisms that have a broad tolerance to fluctuating conditions. Lagoons also tend to contain a narrow range of niches and mainly favour a suite of organisms adapted to shallow, soft sediment habitats (Barnes 1994; 1999). Nevertheless, like estuaries, lagoons are highly productive and important feeding and migratory sites for waterfowl and shorebirds (Nelson-Smith 1977; Barnes 1980; Gillespie et al. 1991).

Morphology

Newfoundland *Chara evoluta* produces a cluster of axes arising from an enlarged basal node anchored in the substrate by rhizoids. Axes up to 23 cm. in length and 520 μm in diameter have been observed from depths of one to several meters, but in very shallow waters plants of only 2 to 3 cm. in length can be commonly found. Main axes are basically haplostichous, that is, having only vertical rows of cortical cells equal in number to the number of branchlets in a whorl. These cortical rows of cells are all primary rows with all rows containing spine cell clusters. Although the haplostichous condition may be quite regular, invariably in this species small secondary cells can be found along the axis between the primary cells producing an imperfect haplostichous condition and showing a tendency towards the diplostichous condition (Figure 2A). Spine cells are produced at the nodes of the cortical cells, sometimes singly, but more often in clusters of two or three. Characteristically, at least one spine cell at a node will be long, up to twice the diameter of the axis, whereas the other one or two are shorter, often being quite tiny and rudimentary (Figure 2A, 2D). Two rows of stipulodes are produced at the base of the branchlets, the cells of the upper row being slightly longer than the lower (Figure 2A, 2B).

Whorls of 9 to 10 branchlets occur at intervals along the axis. Branchlets are corticated with whorls of bract cells at the nodes (Figure 2B). A small ecorticate end cell arises from the terminal whorl. In some collections

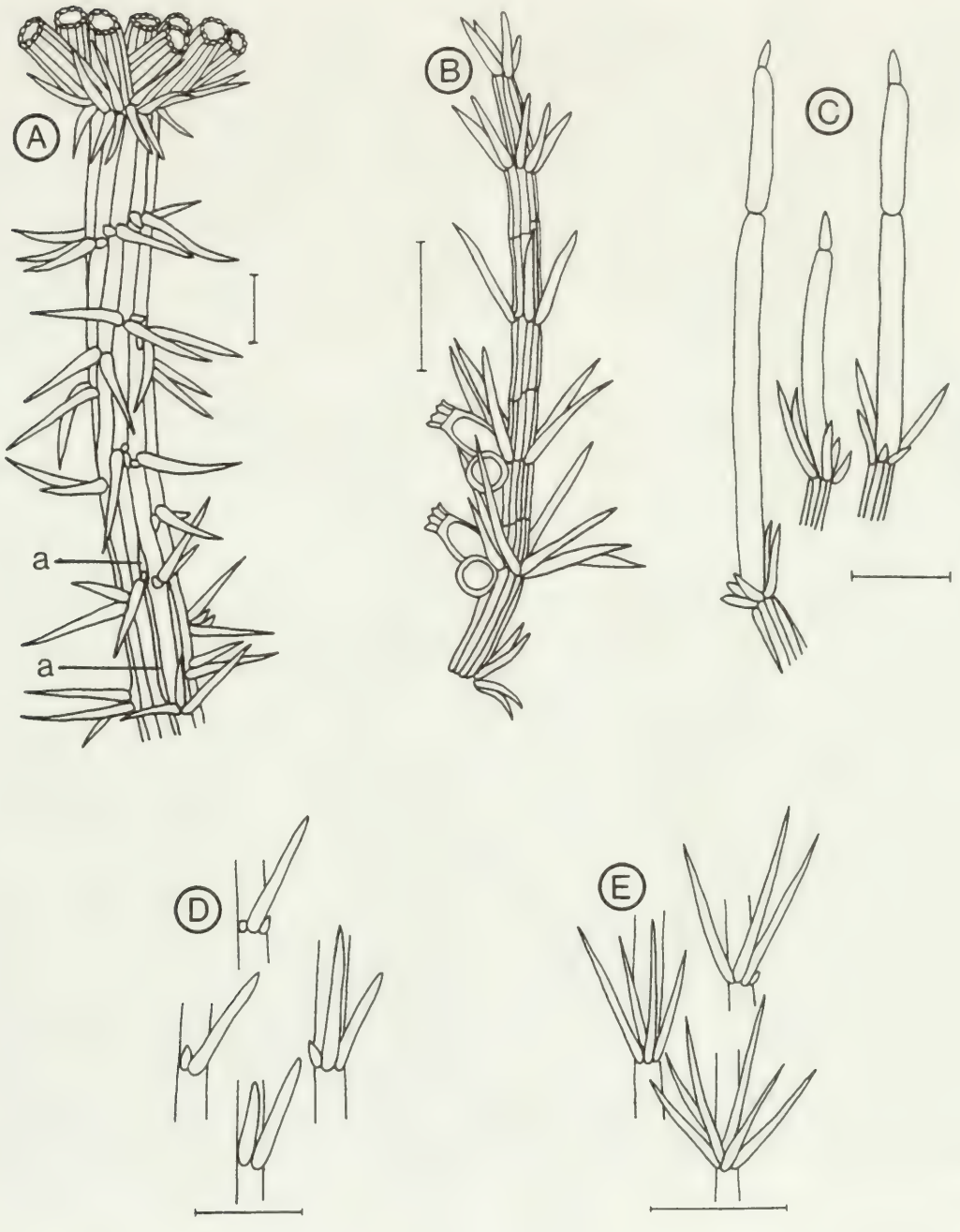

FIGURE 2. Morphological features of *C. evoluta* and *C. canescens*.
A. *C. evoluta* axis - a. secondary cortical cells. Scale bar = 500 µm.
B. *C. evoluta* branchlet. Scale bar = 1000 µm.
C. *C. evoluta* variation in ecorticate end cells of branchlets; unusual, ecologically induced. Scale bar = 1000 µm.
D. *C. evoluta* typical spine cell clusters. Scale bar = 500 µm.
E. *C. canescens* typical spine cell clusters. Scale bar = 1000 µm.

an elongated branchlet extension occurs of 2 or 3 ecorticate end cells (Figure 2C). Invariably these plants have been heavily intermingled with filamentous algal growth so this feature is probably a stress reaction to local biotic or abiotic conditions. This feature is not seen in normal vigorous material growing without obvious competition.

Gametangia, antheridia and oogonia are conjoined at the lowest 2 to 3 branchlet nodes (Figure 2B). Although the antheridia are produced below the oogonia at the nodes, in plants with very short branchlets the internodes are too short to allow antheridia and oogonia to line up above each other and a superficial appearance of two rows is produced with antheridia and oogonia lateral to each other. The two bracteoles on either side of the oogonium are usually shorter or as long as the mature oogonium whereas the bract cells tend to be much longer. Gametangial measurements of *C. evoluta* are listed in Table 1 and compared to those of the lectotype provided by Wood and Imahori (1964). Newfoundland measurements compare favourably with this originally described material from west-

TABLE 1. Gametangial and oospore features of *Chara evoluta* and *Chara canescens*. Measurements are presented as means (μm) with range values in parentheses.

	C. evoluta Newfoundland	*C. evoluta* Wood and Imahori 1964	*C. canescens* Newfoundland	*C. canescens* Wood and Muenscher 1956	*C. canescens* Krause 1997
Oogonium					
length*	931 (816 – 1002)	690 – 810*	759 (620 – 878)	710	550 – 800*
width	474 (372 – 548)	420 – 450	400 (341 – 455)	464	300 – 450
coronula height	128 (103 – 155)	90 – 105	71 (62 – 83)	71	50 – 80
coronula width	249 (207 – 279)	200 – 220	137 (103 – 165)	178	100 – 200
convolutions	(12 – 15)	(13 – 15)	(10 – 15)	(12 – 13)	(11 – 15)
Oospore					
length	601 (517 – 661)	585 – 645	557 (444 – 671)	535	400 – 700
width	338 (227 – 403)	320 – 360	299 (258 – 341)	357	200 – 400
Number of ridges+	(9 – 12)	(10 – 12)	(10 – 14)	11	(10 – 13)
fossae width+	55 (47 – 65)	51	50 (42 – 55)	–	–
Antheridium					
diameter	348 (310 – 393)	300 – 330	–	–	500 – 700

* Length measurements include coronula length except Wood and Imahori (1964) and Krause (1967) which do not.
+ Number of measurements (n) are 100 in all Nfld. features, except oospore No. of ridges (n = 50) and oospore fossae width (n = 30).

ern Canada. Wood and Imahori (1964) state that the antheridia may be 4 scutate, but indicate with a (?) their uncertainty. No other reports mention this feature. All members of the genus *Chara* at present are considered octoscutate with the exception of *C. zeylanica* Klein ex Willd. which is tetrascutate (Proctor et al. 1971). Determining the number of antheridial plates (scutes) in dried herbarium material is often not possible and scutes of liquid preserved material of this species are even difficult to separate clearly. Newfoundland material is distinctly octoscutate and we suspect this is equally true for the lectotype. Characteristic of the oospore are the very low, almost inconspicuous ridges, and the claws of the cage which are almost always present at the base (Figure 3D, 3E). The number of ridges (striae) per oospore ranged from 9 to 12, but most oospores (72%) had 10 or 11.

Chara canescens Desv. & Lois. in Lois. is morphologically very similar to monoecious *C. evoluta*, but is not known to produce antheridia in North America, instead producing oospores parthogenetically. Besides the obvious absence of plants with antheridia, a number of other morphological differences occur, although some being quite subtle unless one is familiar with both species. The best, most obvious, and most constant of these is the comparative size of the coronulas (Table 1, Figure 3C, 3F). Coronulas of *C. evoluta* are almost double the size of *C. canescens* and there is no overlapping in the range values. The tips of the spiral cells just beneath the coronula also tend to enlarge considerably more at maturity in *C. evoluta* than in *C. canescens*. Detached oogonia of the two species can easily be distinguished by these features. Other gametargial measurements (Table 1) are consistently lower in *C. canescens* but not sufficiently to be taxonomically useful. Oospores of *C. canescens* tend to exhibit more ridges with 72% of the oospores having 11 or 12 striae. The striae are also more pronounced than those of *C. evoluta* (Figure 3A, 3D), a feature readily seen with the compound light microscope as well. Basal claws are normally absent, but normally present in *C. evoluta*. Oospore membranes of both species are indistinctly and minutely granular (Figure 3B, 3E). Comparative measurements of North American *C. canescens* are provided by Wood and Muenscher (1956) from New York State (Table 1). European measurements are also given from Krause (1997) although these combine sexual dioecious and parthenogenetic forms as will be discussed in the taxonomic section. All three sets of measurements are fairly consistent for *C. canescens*.

Several subtle vegetative differences also occur between the species. *C. canescens* produces a more perfectly uniform haplostichous axis, only rarely are tiny secondary cells formed between primary cortical rows. Up to 4 to 6 spine cells are normally produced in a cluster (Figure 2E) and all or most tend to be equally long, often twice as long as the axis diameter producing a very spiny appearance. On the other hand, *C. evoluta* normally produces 1 to 3 cells per cluster, one or two often much smaller (Figure 2D).

Taxonomy

Chara evoluta T. F. Allen was first described by T. F. Allen from the Red Deer Lakes and the saline ponds west of the Saskatchewan River (Alberta) based on material collected by J. Macoun (Allen 1882). Founded on a belief that the monoecious/dioecious conditions are not good indicators of species boundaries, Wood (1965) combined *C. evoluta* with dioecious and parthenogenetic taxa under *C. canescens*

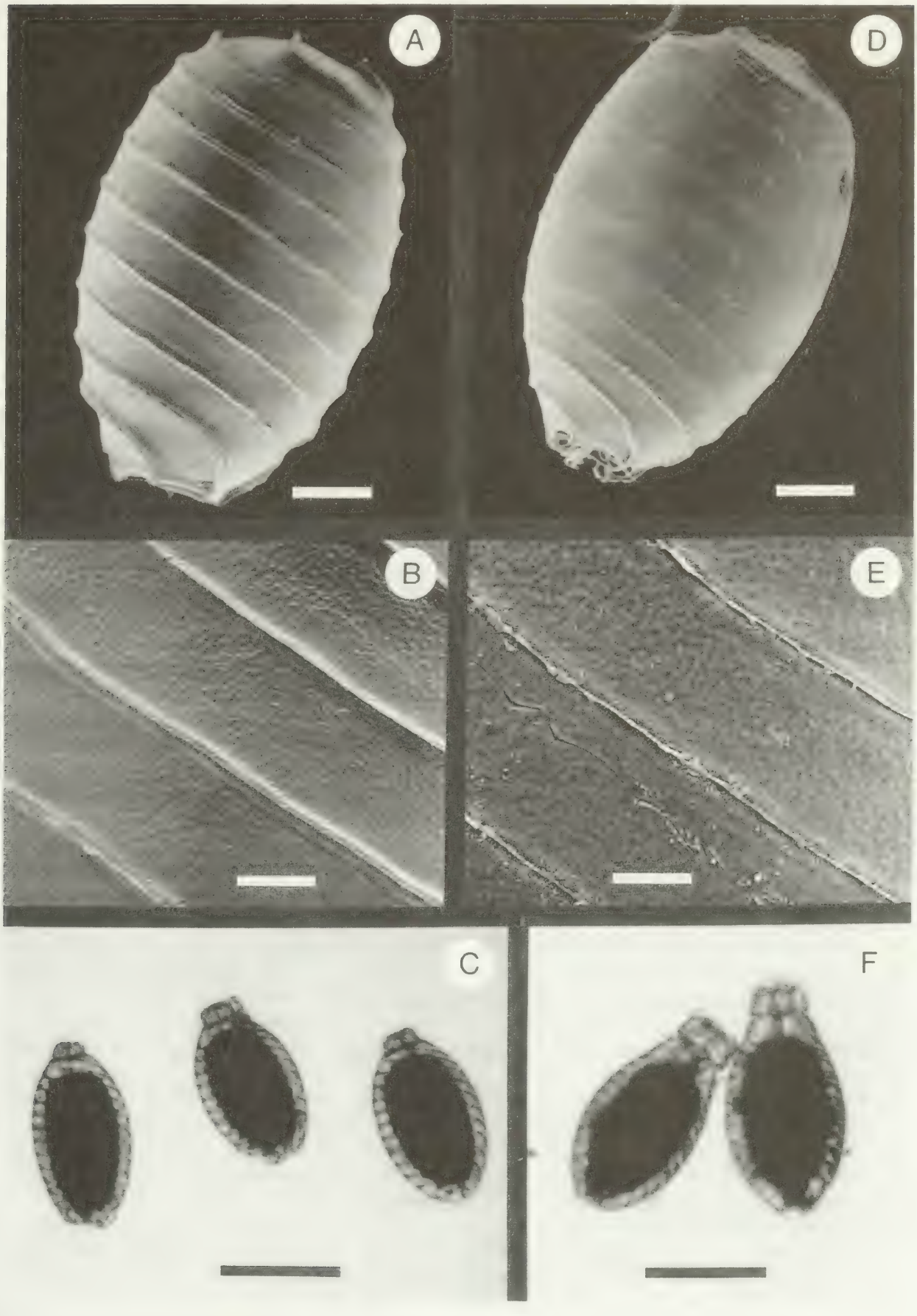

FIGURE 3. Oogonium and oospore features of *C. evoluta* and *C. canescens*.
A. *C. canescens* spore (SEM). Scale bar = 120 µm.
B. *C. canescens* spore membrane (SEM). Scale bar = 30 µm.
C. *C. canescens* oogonia (Light Microscope). Scale bar = 500 µm.
D. *C. evoluta* spore (SEM). Scale bar = 100 µm.
E. *C. evoluta* spore membrane (SEM). Scale bar = 24 µm.
F. *C. evoluta* oogonia (Light Microscope). Scale bar = 500 µm.

Desv. & Lois. in Lois. Subsequently it has been adequately demonstrated that monoecious and dioecious morphologically similar species pairs in charophytes are not conspecific and that Wood's views on this matter are no longer tenable (Proctor 1980). Nevertheless, this combining has led to continuing difficulty in distinguishing taxa in literature reports ever since, a matter especially troublesome for biogeographic purposes.

T. F. Allen (1900) described a very similar taxon which he designated as *Chara hirsuta* from a freshwater pond in California. It is a more robust plant to 60 cm. in height with somewhat larger oospores, more striae, and somewhat more prominent ridges. By comparing the descriptions based on the same material collected from Lakeside, California, by Allen (1900) and others (Robinson 1906; Wood 1965) it becomes apparent that considerable overlap exists in the morphological features of *C. hirsuta* and *C. evoluta*. It has long been understood that morphological variants of charophyte species can often be encountered in isolated bodies of water, but that these minor ecological or genetic variants probably do not indicate reproductive isolation (Robinson 1906; Moore 1986). One report of *C. hirsuta* occurs from Nebraska (Daily and Kiener 1956) and one from Wyoming (Daily and Porter 1961), however, Daily and Kiener (1956) suggest that *C. evoluta* and *C. hirsuta* are probably conspecific. That view was also taken by Proctor (1990) and is accepted here as well, although no evidence other than morphological is available to support this conjecture.

A monoecious, morphologically similar taxon to North American *C. evoluta* has been reported from Asia designated as *C. altaica* A.Br. = *C. sibirica* Mig. (Wood 1965; Hollerbach and Krassavina 1983). The *C. evoluta* taxon has also been reported from China (Han and Li 1994). In light of Proctor's (1980) conjecture that most charophytes are endemic to a single land mass, it remains to be seen whether the North American and Asian taxa are conspecific. To our knowledge no such comparative studies of a morphological, genetic, molecular, or of a breeding nature have yet been undertaken.

North American *Chara canescens* is parthenogenetic; no males have ever been seen. In Europe and Asia there are probably two isolated taxonomic entities within the broadly designated species, a dioecious male/female sexually reproducing entity of restricted range from south-central Europe through central Asia and China and the parthenogenetic entity more widespread across the continent (Krause 1997). Whether male *C. canescens* can fertilize parthenogenetic *C. canescens* has never been demonstrated. The concept of conspecificity is not applicable to parthenogenetic populations which is exemplified by a mutant ecorticate vegetatively reproducing form of *C. canescens* from Svalbard coexisting in the same springpool as a more normal parthenogenetic form (Langangen 2000).

In Newfoundland and elsewhere in North America *C. canescens* and *C. evoluta* sometimes inhabit the same pond. Although the theoretical potential for *C. evoluta* to fertilize *C. canescens* may be suggested, the morphological differences as described previously in this paper remain distinct and no indication of intergradation of features has ever been noted in these situations. This is strong evidence that the two are reproductively isolated and that hybridization does not and cannot occur.

Distribution and Ecology

Chara evoluta in North America has essentially a western distribution, west of the interstate borders connecting the eastern state line of North Dakota with the eastern state line of Texas (Figure 4). Almost all states west of this line have reports in the literature and/or specimens in major herbaria. It is also known from southern British Columbia, Alberta, and Saskatchewan in Canada, but not east of Saskatchewan. It then reappears in a single disjunct location in coastal Rhode Island (Wood 1965; Wood and Palmatier 1954) and again in southwestern Newfoundland. Although thorough charophyte surveys have not been conducted in many areas of North America, some eastern jurisdictions have been variously investigated and *C. evoluta* has not been recorded, further supporting its general absence in the east. These studies include Iowa (Crum 1975), Illinois (Ebinger and Vogel 1977), Indiana (Daily 1953), Minnesota, Wisconsin (Prescott 1962), New York (Wood and Muenscher 1956), West Virginia, Virginia, Tennesse, North Carolina, South Carolina, Georgia, Alabama, Mississippi, Louisianna, Florida (Choudhary and Wood 1973), and others.

Most reports indicate that *C. evoluta* is a species of saline coastal or inland waters. Its western distribution seems to reflect the climatic conditions of low rainfall where rates of evapotranspiration often exceed precipitation to produce saline lakes and ponds which are often closed systems. In some regions geological deposits are also sources of salts (Hammer 1986). Within the stippled region of Figure 4, *C. evoluta* only occurs locally where such saline conditions exist. East of this region rainfall increases, few inland saline habitats occur, and all known collections are from coastal locations influenced by sea water.

Inland and coastal saline waters often differ significantly in their ionic composition. For example, Waldsea Lake, Saskatchewan, is a magnesium-sodium sulphate lake (Hammer 1984) as opposed to marine salinity where sodium and chloride predominate as in the Newfoundland lagoons. Waldsea water has a conductivity and pH in the same range as the Newfoundland lagoons and both *C. evoluta* and *C. canescens* are known to occur in Waldsea Lake as well as *C. buckellii* G. O. Allen. Hammer et al. (1983) indicate that the Na/Mg ratio plays an important role in governing the occurrence of algal species in lakes. *C. evoluta* appears

to be capable of adapting to chemically different salinities, but also to a wide range of salinities. Winter and Kirst (1991) and Winter et al. (1996) determined that *C. canescens* has an upper salinity tolerance in the mesohaline range of approximately 20 parts per thousand (ppt) and a lower limit of 1.5 ppt in the low oligohaline range. It may be assumed that this is equally probable for *C. evoluta* since both are often associates in inland and coastal waters. A few authors report *C. evoluta* from non-saline freshwater habitats (Allen 1900; Leake 1945). Also V. W. Proctor (personal communication) indicates that both species can be successfully cultured under low salinity conditions to produce viable oospores. Brock (1986), however, suggests that for submerged aquatic plants in saline environments, extremes of tolerance are not the primary factors in determining the flora, but rather evolved life cycle mechanisms which allow survival under widely fluctuating conditions. Thus fluctuating salinities and/or ephemeral habitats would foster different floras than permanent water bodies with little salinity fluctuation.

Some degree of salinity and/or particular ionic composition appears to be required by *C. evoluta* (and *C. canescens*), but within this broad tolerance range from lower oligohaline (oligosaline) to mesohaline (mesosaline), presence or absence in water bodies may be a function of biotic community structure. This concept suggests that salinity may set the extreme boundaries for such species, but that community structure including competition, predation, herbivory, allelopathy, and others may determine the colonization ability of any given species. Barnes (1999) states that there is evidence that brackish water communities are not physically structured by salinity, but by biotic processes such as predation and competition. Although it is tempting to suggest that *C. evoluta*'s apparent absence from continental eastern North America is due to the absence of any significant saline waters, this may be an oversimplification. Even when dispersed, ability to establish, grow, and reproduce in complexly evolved communities may not be possible despite favourable physical parameters. For example, a relationship between the presence of certain invertebrate herbivores and the distribution of charophyte species has been demonstrated by Proctor (1990, 1999).

In Newfoundland *C. evoluta* grows in association with *Chara aspera* in the five southernmost lagoons and Codroy Estuary Pond (Table 2). In these lagoons *C. aspera* is very common, as is *C. evoluta*, but no other charophytes occur. This *C. evoluta*/*C. aspera* association is also recorded from interior British Columbia (Allen 1951), Rhode Island (Wood and Palmatier 1954), and Nebraska (Daily and Kiener 1956). In the two northern lagoons (Gravels Pond and St. George's Pond) *C. evoluta* grows with *C. canescens*, but *C. aspera* is absent. The *C. evoluta*/*C. canescens* association is reported from Waldsea Lake, Saskatchewan, and Roses Pond (Sweets Lake), British Columbia, where they both grow with *Chara buckellii*, but *C.*

FIGURE 4. Distribution of *Chara evoluta* in North America. The stippled area indicates its western distribution. The two dots indicate the only known eastern sites.

aspera is apparently absent. The *C. canscens*/*C. aspera* combination is recorded for Rhode Island (Wood 1950) and reported as a common associate in both North America and Europe (Allen 1882; Krause 1997). *C. canescens* has not yet been collected in association with *C. aspera* in Newfoundland, and neither here, nor in any other reports have all three species ever been reported from the same body of water. Based on two well-known ecological principles of competitive exclusion and of coexistence, it is tempting to try and ascribe some ecological significance to this apparent pattern of species associations, but such an attempt may be premature without a thorough comparison of site conditions, both biotic and abiotic.

Chara aspera has a broad North American range, commonly occurring in permanent sites from coast to coast in southern Canada and tapering to and becoming more infrequent in Mexico (Croy 1982). It occurs more commonly in freshwater situations than either *C. canescens* and *C. evoluta*, but has an extremely broad salt tolerance (Langangen 1974). It is common in the Newfoundland upper estuaries of the Little Codroy and the Codroy River, however has not been collected further north. Ripe oospores have not yet been observed for this species in Newfoundland despite collections ranging over many years and all summer seasons. Dispersal by waterfowl via the many round white bulbils produced on the rhizoids of this species

TABLE 2. Charophytes present in the coastal lagoons/ponds of southwestern Newfoundland investigated in this study.

	C. evoluta	*C. canescens*	*C. aspera*	*C. globularis*
Gravels Pond	X	X		
St. George's Pond	X	X		X
Codroy Estuary Pond	X		X	
Osmond Pond	X		X	
Rocky Barachois	X		X	
Saltwater Pond	X		X	
Second Pond	X		X	
First Pond	X		X	

may be considerably more haphazard and infrequent than dispersal by spores and may account for its absence in the two northern lagoons. However, other abiotic/biotic differences as yet undetermined may also be involved.

Chara globularis Thuill. (= *C. delicatula* Agardh) grows in St. George's Lagoon, the site with the lowest recorded salinity. Although this species is normally associated with fresh water, it has quite a broad tolerance range and is occasionally reported from low salinity waters (Winter and Kirst 1991). It is the most common *Chara* in Newfoundland.

Relatively few vascular taxa inhabit brackish waters. Those associated with charophytes in all the Newfoundland lagoons include Sago Pondweed, Horned Pondweed, and Widgeon-grass. These cosmopolitan vasculars of saline coastal and inland waters all belong to closely related families and are important food sources for waterfowl, as are charophytes. These vasculars are common throughout their ranges wherever brackish conditions occur (Melack 1988) although all can also occur in alkaline freshwaters (Hammer and Heseltine 1988).

It is well accepted that charophyte spores are readily dispersed by waterfowl and shore birds, even great distances (Kristiansen 1996). The disjunct Rhode Island *C. evoluta* site may be attributed to such long distance dispersal as considerable east-west exchange also occurs in addition to the normal north-south migratory routes of waterfowl (Bellrose 1976). Undoubtedly more coastal populations of *C. evoluta* occur along the Atlantic seaboard wherever suitable conditions exist. The Newfoundland populations are almost certainly a northward dispersal since the last glaciation via the Atlantic Flyway.

North American parthenogenetic *C. canescens* exhibits a similar range to *C. evoluta*, but tends to have a more sporadic occurrence as one moves south from western Canada. It ranges up the eastern seaboard into Newfoundland, Greenland, Svalbard, and into Europe and Asia where many forms and varieties have been described. It too is reported occasionally from fresh or oligohaline waters (Olsen 1944; Prescott 1962; Winter and Kirst 1991; Langangen 2000). Langangen (2000) suggests that the reason that *C. canescens* is not normally found at low salinities in Europe may be due to competition from other plants which flourish at low salinities, but are excluded at higher salinities. It might also be suggested that at the lower salinities, increased herbivore pressure may also become a factor (Proctor 1999).

As there are no distinct morphological differences between *C. canescens* of the eastern seaboard and that of Newfoundland lagoons (Table 1) it can be assumed that this species, like *C. evoluta*, entered Newfoundland from the south via the Atlantic Flyway. However, because of its northern distribution an arctic route cannot be ruled out (Mann 1994a).

Key to Newfoundland Species

The following key is provided specifically to identify the taxa known to occur in Newfoundland and Labrador. For an explanation of charophyte structure and terminology we recommend Groves and Bullock-Webster (1920, 1924), G. O. Allen (1950), and Moore (1986). Recommended more general keys to the entire North American charophyte flora include Robinson (1906) for the Genus *Chara*, Wood (1948) for the Genus *Nitella*, and G. O. Allen (1954) for Genera *Nitella* and *Tolypella*. Wood (1965, 1967) and Wood and Imahori (1964) are essential references for advanced studies, but the combining of some species in these works discourages the reporting of many good taxa. It is recommended that Newfoundland workers identify taxa using the currently supplied key and when uncertain, consult a specialist. There is always the possibility that species new to the province may be discovered in the future, but such will almost certainly be rare or uncommon in our flora.

1a Coronula of 5 cells in one tier, cortical cells usually present on the main axis, stipulodes present – (Chara) 5

1b Coronula of 10 cells in two tiers of 5, axes always without cortication, stipulodes absent 2

2a Oogonia and oospores round in cross section, branchlets consisting of a main axis with smaller laterals – *Tolypella* . . . . . *Tolypella glomerata* (Desv.) Leonh. This is our only known *Tolypella*

2b Oogonia and oospores somewhat flattened in cross-section, branchlets forking usually equally one or more times (*Nitella*) 3

3a Unbranched end segments of branchlets (dactyls) of more than one cell, end cell tiny and pointed ..... *Nitella confervacea* (Breb.) A. Braun

3b Unbranched end segments of branchlets (dactyls) of one cell (*N. flexilis* group) 4

4a Plants monoecious (antheridia and oogonia on same plants) ..... *Nitella flexilis* (L.) Agardh

4b Plants dioecious (antheridia and oogonia on separate plants) ..... *Nitella opaca* Agardh

5a Axial cortex composed only of primary rows of cells (all rows contain spine cells = haplostichous), Axes bristly with many long spines 6

5b Axial cortex of primary rows with spine cells alternating with one or two secondary rows without spine cells, Axes not greatly spiny 7

6a Plants monoecious (antheridia and oogonia on same plants), coronula width over 180 µm ..... *Chara evoluta* T. F. Allen

6b Plants only with oogonia, no males with antheridia known in North America, coronula less than 180 µm wide ..... *Chara canescens* Desv. & Lois. in Lois.

7a Axial cortex having each primary row alternating with one secondary row (diplostichous) 8

7b Axial cortex having each primary row alternating with two secondary rows (triplostichous) 9

8a Primary axial cortical rows of cells more prominent than the secondary rows ..... *Chara contraria* A. Brown ex Kütz

8b Primary axial cortical rows of cells less prominent than the secondary rows .... *Chara vulgaris* L.

9a Plants dioecious, upper and lower stipulodes well developed, rhizoids often with tiny spherical white bulbils ..... *Chara aspera* Deth.ex Willd

9b Plant monoecious, stipulodes especially lower ones rudimentary, globular; rhizoids without bulbils 10

10a Primary cortical rows more prominent than secondary rows (tylacanthous), upper row of stipulodes more elongate than globular lower row (sometimes only slightly) ..... *Chara delicatula* Agardh non Desv.*

10b Primary cortical row and secondary rows equal in size (isostichous), both upper and lower stipulode rows of rudimentary globular cells ..... *Chara globularis* Thuill (= *C. fragilis* Desv.)*

* These two taxa may show ecologically induced intergrading forms and in some treatments are combined under *C. globularis* Thuill. They should, however, always be distinguished separately whenever possible until their taxonomy can be more precisely defined.

Discussion

Insular Newfoundland has a depauperate vascular flora compared to the adjacent mainland largely due to dispersal difficulty across the straits and to climatic and edaphic factors resulting in less diverse habitats (Damman 1965). On the other hand, the charophyte flora compares favorably numerically with many other parts of northern North America (Mann et al. 1999). It is well known that charophytes are rapid early colonizers of disturbed habitats (Olsen 1944) suggesting that dispersal is not a significant limiting factor for this group, especially within a single land mass. Almost invariably if suitable habitat exists, it will become colonized by charophyte species normally occupying those particular biotic and abiotic parameters.

Those Newfoundland taxa with broad ecological tolerances commonly occur across North America, including *C. globularis*, *C. delicatula*, *C. contraria*, *C. vulgaris*, *N. flexilis*, and *N. opaca*. These are species of permanently inundated and relatively stable habitats after formation. *C. globularis* and *C. delicatula* as defined in this paper, in addition to *N. flexilis* and *N. opaca*, are most tolerant of oligotrophic acid waters and are ubiquitous across the Island (Mann 1989). Of this group, *C. delicatula* is the most tolerant of saline conditions and can commonly be found in coastal areas subject to some marine influence. *C. contraria* and *C. vulgaris* are species of high pH waters, commonly the limestone areas of the west coast, but also in very high pH serpentine pools and of coastal low-saline habitats.

The other portion of the Newfoundland charophyte flora is made up of species with more narrowly defined habitats, where habitats are rare on the Island and therefore the species themselves are rare. The three species featured in this paper (*C. evoluta*, *C. canescens*, *C. aspera*) are restricted to soft-bottomed, fluctuating saline habitats which are only relatively common on the southwest coast. *Tolypella glomerata* is restricted to coastal freshwater ephemeral sites or their equivalents which are decidedly uncommon here. *Nitella confervacea* is restricted to two west coast sites whose common ecological features are still unclear. In all of these five rare species, fluctuating and regular habitat disturbance are common factors, and all are of coastal distribution because this is the only area where habitat suitable for their growth occurs. These five rare species exhibit a disjunct distribution with the New England states. None have yet been reported for the maritime provinces or adjacent Quebec. If suitable habitat for these species exists in the Maritimes, this disjunct distribution may prove to be an illusion of insufficient field observation.

It has been determined that disjunct Newfoundland *Chara evoluta* and *Chara canescens* populations are morphologically and ecologically similar to their counterparts elsewhere in North America suggesting relatively recent introductions from the south. The two taxa can readily be distinguished by their monoecious/dioecious (parthenogenetic) conditions respectively and by oospore and oogonial features. However, other subtle differences also may suggest the possibility that at least some morphology may be due to convergent adaptation rather than divergent evolution from recent com-

mon ancestors. Their distribution in North America is ascribed to their affinity for saline waters. Although ecologically similar, there is some indication that their niches do not totally overlap and that their salinity tolerance ranges far exceed their actual ecological ranges leading one to suspect that biotic factors may be equally important in determining presence or absence in a given body of water, and therefore their total biogeography.

The coastal lagoons of south-west Newfoundland are unique habitats adding to the provincial biodiversity by harbouring highly disjunct charophyte species within the North American continental perspective. Three species, *C. evoluta*, *C. canescens*, and *C. aspera* are restricted to this region and have been accorded rare status in Newfoundland (Mann 2000*). Along with estuaries in the region (Gillespie et al. 1991), lagoons provide important feeding and migratory habitat for waterfowl and shorebirds, including the endangered Piping Plover which nests on the sandy outer beaches (Hancock, J. 2001*; Knox et al. 1994). The Banded Killifish listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2000*) as a species of special concern in Newfoundland also occurs in the lagoons. Much is still unknown about the detailed flora/fauna and the community structure in these saline water bodies. Being sites that can easily be altered and degraded by human activity (Martin et al. 2002; Barnes 1980), their unique features need to be further documented in detail and some degree of protection should be considered within the developing provincial strategy.

Acknowledgments

We thank V. W. Proctor, M. V. S. Raju, and A. Langangen for their comments and suggestions. Thanks to Tony Dickinson for identification of the Banded Killifish and to Claudia Hanel for reporting the Codroy Estuary site. Greatfully acknowledged are Ellen Block and Barbara Thiers for specimen loans from the New York Botanical Garden (NY). Loans from the Field Museum of Natural History, Chicago (F) were also helpful.

This study was partially funded from the Principal's Research Fund, Sir Wilfred Grenfell College, and a Sabbatical Grant from Memorial University.

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Received 23 September 2003
Accepted 21 February 2005

The Effect of Human Activity on Ant Species (Hymenoptera: Formicidae) Richness at the Mont St. Hilaire Biosphere Reserve, Québec

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Shik, Jonathan, André Francoeur, and Christopher Buddle. 2005. The effect of human activity on ant species (Hymenoptera: Formicidae) richness at the Mont St. Hilaire Biosphere Reserve, Québec. Canadian Field-Naturalist 119(1): 38-42.

The ant (Hymenoptera: Formicidae) fauna of the Mont St. Hilaire Biosphere Reserve, Québec, was surveyed in 2002 and 2003. Although overall species richness was high, 10 of 40 total ant species collected were limited to anthropogenically disturbed habitats within the reserve. While only 2 of these 10 species (*Tetramorium caespitum* (L.) and *Lasius niger* (L.)) can definitively be considered introduced, areas altered by human activity (representing a small fraction of the reserve's total area) possess nearly as many unique species as the reserve's old-growth forest. Although further research will be necessary to determine the consequences of such changes in community structure, this study shows the importance of specifying the extent of biodiversity surveys within protected habitats to more accurately monitor the effectiveness of conservation efforts.

Key Words: ants, Hymenoptera: Formicidae, Mont St. Hilaire, anthropogenic disturbance, old-growth forest, species richness, inventory.

Mont St. Hilaire, protected as an International Biosphere Reserve under the Man and Biosphere program of the United Nations, is the largest remaining tract of old-growth deciduous forest in the St. Lawrence Valley (Arii and Lechowicz 2002). Although dominated by Sugar Maple (*Acer saccharum*) and American Beech (*Fagus grandifolia*), this 10 km^2 old-growth forest contains diverse habitats including exposed summits rising 200–300 m above the surrounding forest, low productivity bogs dominated by Hemlock (*Tsuga canadensis*), and stands of Red Oak (*Quercus rubr*a) and Red and White pine (*Pinus resinosa and P. strobus*). Located within a suburban setting approximately 32 km east of Montréal, Mont St. Hilaire (45°55'N; 75°13'W) also contains areas of anthropogenic disturbance. We sought to survey the ant species richness (Hymenoptera: Formicidae) at Mont St. Hilaire and determine whether human activities within and adjacent to the Biosphere Reserve have effects on the fauna.

Methods

Between 6 May and 31 July 2002, JZS [Jonathan Z. Shik] intensively hand-collected ants (243 samples, about 7500 individuals) within the boundaries of Mont St. Hilaire. Within a given habitat, individual foragers and colonies were collected in both hypogeous (e.g., under rocks, in leaf litter, and under decaying wood) and epigeous (e.g., on living vegetation, along roadsides, and on mosses and boulders) microhabitats. Additional colony sampling (56 samples) conducted by JZS and AF [André Francoeur] from 7 to 10 July 2003 verified species distributions and yielded two species not recorded in 2002 (*Brachymyrmex depilis* (Emery), and *Leptothorax ergatogyneus* (Francoeur)). Voucher specimens have been deposited in the Lyman Entomological Museum (McGill University, Macdonald Campus, Ste. Anne de Bellevue, Québec).

Because ant distributions vary along abiotic gradients of temperature and moisture that depend on exposure to sunlight (Brown 1973), ants were sampled in both "vegetated" (plant community covers the ground) and "exposed" (unshaded rocky) areas. To assess effects of human activity within these two habitat groupings, both natural and anthropogenically disturbed (henceforth, "disturbed") habitat were sampled (Table 1). Natural vegetated habitat consisted of old growth forest, while disturbed areas were mid-successional fields, isolated patches of secondary forest near boundaries, and areas dominated by introduced vegetation, especially artificially maintained grass areas near buildings. Natural exposed areas were unshaded boulders at summits, and rocky outcrops within the forest while disturbed exposed areas were roadsides and the unshaded gravel of parking lots and a sandy picnic area.

Results

The ant survey yielded 40 species spread across 17 genera, making it one of the most species rich localities in the eastern Canadian boreal-broadleaved tran-

TABLE 1. Summary of ants (Hymenoptera: Formicidae) collected at the Mont. St. Hilaire biosphere reserve. Numbers indicate number of direct observations by species and habitat type. Vegetative habitats are collections made on or beneath vegetation (shaded), exposed refers to lack of direct shading. Anthropogenic habitats are defined by proximity to human buildings or roads. The symbol * represent natural habitat specialists (>90% of observations in natural habitats), † refers to specialists of anthropogenic habitats, no symbol represents generalist. Species are identified according to Creighton (1950) or more recent generic revisions as stated in Bolton (1995). The *Myrmica* species follow the upcoming taxonomic revision of the nearctic species by A. Francoeur (unpublished).

	Natural				Anthropogenically Disturbed				
	Vegetated			Exposed	Vegetated		Exposed		
	Old-growth forest	Summit	Rock outcrop (forest)	Field (mid-succession)	Grass (building)	Isolated forest	Parking lot gravel, sandy picnic area	Road-side	Total Number of Observations
SUBFAMILY PONERINES									
Ambylpone pallipes (Haldeman)*	5								5
Ponera pennsylvanica (Buckley)†						3	1	1	5
SUBFAMILY MYRMICINES									
Aphaenogaster rudis (Emery)	9		1			4		1	15
Crematogaster cerasi (Fitch)	1					2			3
Leptothorax ambiguus (Emery)†				1					1
L. canadensis (Provancher)	2	3				1			6
L. ergatogyneus (Francoeur)*		1							1
L. longispinosus (Roger)	21	2	2			5			30
Myrmecina americana (Emery)	2					2			4
Myrmica detritinodis (Emery)*		4	1						5
M. emeryana (Forel)	2					1			3
M. fracticornis (Emery)			1	4					5
M. pinetorum (Wheeler)*		1							1
M. punctiventris (Roger)	4					1			5
M. sculptilis, n.sp. (Francoeur)	4	11				6			21
Solenopsis molesta (Say)†						2	1		3
Stenamma diecki (Emery)*	3								3
S. impar (Forel)*	2								2
Tetramorium caespitum (Linnaeus)†					1			8	9
SUBFAMILY DOLICHODERINES									
Dolichoderus plagiatus (Mayr)*		4							4
Tapinoma sessile (Say)		5				1	3	2	11
SUBFAMILY FORMICINES									
Acanthomyops subglaber (Emery)*	1								1
Brachymyrmex depilis (Emery)	1				1				2
Camponotus nearcticus (Emery)*	14					1			15
C. novaeboracensis (Fitch)	3		2			2			7
C. pennsylvanicus (De Geer)	10	2	1			1		1	15
Formica glacialis (Wheeler)	3	3	1					2	9
F. lasioides (Emery)†						1			1

TABLE 1. (*continued*)

	Natural					Anthropogenically Disturbed			
	Vegetated		Exposed			Vegetated		Exposed	
	Old-growth forest	Summit	Rock outcrop (forest)	Field (mid-succession)	Grass (building)	Isolated forest	Parking lot gravel, sandy · picnic area	Road-side	Total Number of Observations
F. neogagates (Emery)*	8	15	2	1					26
F. nepticula (Wheeler)*		2	1						3
F. nitidiventris (Emery)†						2	6	1	9
F. subaenescens (Emery)*	7								7
F. aserva (Wheeler)†							3	2	5
F. subsericea (Say)		1			1	2	3		7
Lasius alienus (Foerster)*	9	5				1			15
L. nearcticus (Wheeler)*	12		1						13
L. neoniger (Emery)†						2	2	6	10
L. niger (Linnaeus)†								3	3
L. pallitarsis (Provancher)†						2	1		3
L. umbratus (Nylander)	2		1			2	1		6
Total observations	125	59	14	6	3	44	21	27	299
Number of species per habitat	22	14	11	3	3	21	9	10	

sition forests (Table 1). Of this total, 10 species were most commonly collected (i.e., occurred >90% of the sampling observations) in disturbed habitat (disturbance specialists), 14 species could be considered specialists in natural habitat (>90% of observations in natural habitats), and 16 are considered habitat generalists, being found frequently in both natural and disturbed habitat (Table 1). Five of the 10 disturbance specialists (*Leptothorax ambiguus* (Emery), *Solenopsis molesta* (Say), *Formica lasioides* (Emery), *Lasius niger* (L.), and *L. pallitarsis* (Provancher)) were sampled three or less times during the course of the study (Table 1). We believe this represents true rarity rather than collection bias as most of these species were readily detected, being found in epigeous habitat. Only *Ponera pennsylvanica* (Buckley), *S. molesta* and *F. lasioides*, might have been overlooked in nearby primary forest due to being found only under rocks and under litter at the soil surface.

Discussion

At first glance, ant species richness at Mont St. Hilaire—a forest reserve of limited area—is exceptionally high. Surveys of natural and disturbed biotopes in the much larger areas of Châteauguay and Huntington municipal counties in Québec just south of Montréal yielded 48 species (A. Francoeur, unpublished data), 81% of which exist at Mont St. Hilaire. However, when considering that only 30 of Mont St. Hilaire's 40 species were found in natural habitats, diversity "within" the interior of the reserve is not higher than within other similar forests. For example, Letendre et al. (1971) found 29 species (22 of which occur at Mont St. Hilaire), in post-fire Paper Birch (*Betula papyrifera*), poplar (*Populus* sp.) and Sugar Maple forest at the Université de Montréal field station (9 km^2), 80 km northwest of Montréal.

Two of the disturbance specialists are considered introduced. The presence of *Lasius niger* (L.) represents a significant extension to its range as it is known as a west coast species (Wilson 1955). While collections within the city of Montréal suggest that this species is established in the region, additional collecting may help determine if *L. niger* is introduced from the west or occupies an undocumented larger range. *Tetramorium caespitum* (L.), a globally distributed tramp species native to Europe (Bolton 1979), was found only along roadsides leading to the park's main entrance. Because the other eight disturbance specialists are native to the nearctic region, their historical presence or absence at Mont St. Hilaire is unknown. It is apparent, however, that within habitat modified by humans these ant species presently exhibit increased abundance relative to natural areas such that within the protected reserve human activity has altered ant community structure.

Anthropogenically disturbed and fragmented habitat becomes increasingly vulnerable to the establishment of introduced ant species (Tschinkel 1988; Suarez et al. 1998). Human traffic could potentially serve as a vector for further ant introductions in the reserve's disturbed areas that represent a small percentage of Mont St. Hilaire's total area, but already house a large number of unique species—nearly as many as natural areas. Although Québec presently lacks the most notorious invasive species that are ravaging the native ant faunas of other regions (Francoeur 2000; Holway et al. 2002), the introduction of any species should be closely monitored in reserves that are amongst the last remnants of their habitat type. While further research will be necessary to determine the nature of interactions between disturbance and natural specialists, we believe that the reserve's old-growth forest ant fauna should be considered as a community marked by scattered disturbance subpopulations. More generally, these findings illustrate the importance of clearly delineating natural from anthropogenically disturbed habitat when conducting biodiversity surveys within special reserves such as Mont St. Hilaire.

Acknowledgments

We thank M. Lechowicz, B. Gilbert, E. Lo, H. Varady-Szabo, T. Smith, B. Hamel, the Gault Nature Reserve, and the Lyman Entomological Museum of McGill University. Comments from anonymous reviewers improved this manuscript. Funding was provided in part by NSERC (M. Lechowicz, Department Biology, McGill University, and C. Buddle).

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Received 20 November 2003
Accepted 28 January 2005

Seasonal Diets of Newfoundland Martens, *Martes americana atrata*

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Gosse, John W., and Brian J. Hearn. 2005. Seasonal diets of Newfoundland Martens, *Martes americana atrata*. Canadian Field-Naturalist 119(1): 43-47.

We analyzed scats (n = 679) and stomach contents (n = 25) collected from 1980-2003 to assess the relative frequencies of food types utilized by Newfoundland Marten (*Martes americana atrata*) during summer and winter. Meadow Voles (*Microtus pennsylvanicus*) were the most prevalent food item occurring in 80% and 47.5% of samples from summer and winter, respectively. Apart from Snowshoe Hares (*Lepus americana*), which occurred in 28% of winter samples, all other food types occurred in <16% of samples during each season. Diet breadth was widest during winter and may be related to a lower availability of Meadow Voles during this time of year.

Key Words: Newfoundland Marten, *Martes americana atrata*, diet, food habits, Meadow Voles, *Microtus pennsylvanicus*, *scat*.

The Newfoundland Marten (*Martes americana atrata*) is one of only 14 native terrestrial mammals on the island of Newfoundland (Dodds 1983) and is currently listed by the Committee on the Status of Endangered Wildlife in Canada as Endangered. Though this species has been the focus of considerable research, basic information on seasonal diet patterns of Newfoundland Marten is lacking.

The potential prey base for Newfoundland Marten, a genetically distinct subspecies (Kyle and Strobeck 2003) of the American Marten (*Martes americana*), is limited. Newfoundland has a reduced diversity of small mammal prey species (8 species) compared with neighboring mainland areas such as Labrador (17 species) and Nova Scotia (23 species; Tucker 1988). Further, only one arvicoline rodent, the Meadow Vole (*Microtus pennsylvanicus*), fully overlaps with, and occurs in forested habitats used by Marten (Thompson and Curran 1995; Tucker 1988; Sturtevant and Bissonette 1997).

Home range size of Marten on the island of Newfoundland is exceptionally large (Bateman 1986; B. Hearn, unpublished data). Gosse (*In press* Journal of Mammalogy) and may reflect the low diversity and abundance of small and medium-sized mammals (Lindstedt et al. 1986; Thompson and Colgan 1987). Southern Red-backed Voles (*Clethrionomys gapperi*), a major food item of marten across their North American range (Buskirk and MacDonald 1984; Simon et al. 1999), were first recorded in western Newfoundland in 1999 and their distribution and abundance is expanding (Hearn et al. 2005). Herein we report the diversity of food types consumed by Newfoundland Marten over an 18-year period prior to the widespread establishment of Southern Red-backed Voles on the island. This study will provide insight into the feeding ecology of Newfoundland Marten and will allow future comparisons of foraging patterns following expected changes in small mammal communities.

Study Area and Methods

Scats were collected opportunistically during field studies between 1995-2003 and were air and/or oven-dried prior to storage. Most scats (70%) were collected near Little Grand Lake in western Newfoundland (57°50'00N, 48°38'00W) prior to 1999. The remainder was collected in Terra Nova National Park in eastern Newfoundland (53°50'00N, 48°30'W). Stomachs from carcasses turned in by trappers in western Newfoundland were refrigerated and washed prior to examination. Prey items were identified based on the coloration and banding patterns of mammalian guard hairs, and on the remains of indigestible material including teeth, feathers, seeds and insect exoskeletons; a reference collection and an identification manual (Adorjan and Kolenosky 1969) aided in this process. We pooled these data with other published (Bateman 1986) and unpublished (Snyder 1986*; Tucker 1988; Drew 1994) data on food habits of Newfoundland marten collected from 1980 to 1991 (Table 1). Samples were categorized by season (winter, 1 November to 31 April; summer, 1 May to 31 October) whenever possible. Prey items were placed into one of 10 categories: (1) Meadow Voles, (2) Southern Red-backed Voles, (3) Masked Shrews (*Sorex cinereus*), (4) Snowshoe Hares (*Lepus americanus*), (5) Red Squirrels (*Tamiasciurus hudsonicus*), (6) unidentified mammals, (7) Moose (*Alces alces*) and Caribou (*Rangifer tarandus*) carrion, (8) insects, (9) avian remains, and (10) berries. Samples collected during earlier studies (Bateman

TABLE 1. Data source, collection period, and number of samples collected.

Data source	Number of samples	Sampling period
M. Bateman (1986)	56	1980-1982
J. Snyder (1986*)	25[a]	1984-1986
B. Tucker (1988)	194	1986-1987
G. Drew (1994)	12	1990-1991
This study	417	1995-2003
Total	704	1980-2003

a = stomach contents from carcasses.

1986; Snyder 1986*; Tucker 1988; Drew 1994) were analyzed by the original investigators using similar techniques. Contents are expressed as frequency of occurrence rather than volumetric estimates to maintain consistency with earlier reporting. Furthermore, volumetric estimates of prey items would provide little additional information since most scats were entirely composed of one food type. Shannon diversity indices (Krebs 1998) were calculated for samples collected during summer, winter, and for both seasons combined. Samples were not partitioned according to sex since the sex of the animal depositing the scat was known for <15% of the samples. Moreover, previous studies indicate that significant differences in inter-sexual diet are not apparent (Nagorsen et al. 1989; Nagorsen et al. 1991; Thompson and Colgan 1990; Simon et al. 1999).

Results

A total of 704 samples (679 scats and 25 stomach contents) were collected from 1980-2003 (Table 2). Meadow Voles were the most prevalent prey item in scats and stomach contents, occurring in 70.5% of all samples (pooled over sites, seasons, and years). Snowshoe Hares were the second most frequent prey item. Other food types consumed by Marten included Masked Shrews, Red Squirrels, Moose and Caribou carrion, insects, birds, berries, and unidentified mammals; however, overall frequency of occurrence for each of these items was <10%. Southern Red-backed Vole remains were found in a single scat collected near Little Grand Lake in 1999; this coincides with the first record of this species on the island of Newfoundland (Hearn et al. 2005). Insect exoskeletons were identified as vespid wasps. Most bird remains were from smaller passerines, however, Ruffed Grouse (*Bonasa umbellus*) and Willow Ptarmigan (*Lagopus lagopus*) were identified from samples collected in southwestern Newfoundland during the winters of 1980-1982 (Bateman 1986). Eggshells were also found in several scats. Scats contained a variety of berries including Creeping Snowberry (*Gaultheria hispidula*), Wild Sarsparilla (*Aralia nudicaulis*), blueberry (*Vaccinium* spp.), Bunchberry (*Cornus canadensis*), Common Raspberry (*Rubus idaeus*), and Three-Leaved False Solomon's Seal (*Smilacina trifolia*). The Shannon diversity index for the pooled data was 1.6. Eighty-eight percent of scats contained only one food item, consequently, the importance of larger prey items such as Snowshoe Hare and carrion is likely under-represented (Poole and Graf 1996; Cumberland et al. 2001) since these foods result in the production of fewer scats due to a lack of indigestible material per volume of food ingested (Zielinski 1986).

Comparisons of summer and winter diet pattern indicated that Meadow Voles were the most prevalent food item throughout the year, though frequency of occurrence was nearly double during summer (Table 2). Berries were the second most common food type found in samples collected in the summer. In winter, 28% of samples contained Snowshoe Hare remains indicating a 10-fold increase in use of this food item compared with summer. The frequency of Masked Shrews and birds was consistent between seasons though both food categories occurred in relatively few samples (Table 2). All other food types, except for berries and insects, which are highly seasonal food items, had higher percentages of occurrence in winter. This more balanced occurrence of food types in winter samples resulted in a higher diversity index ($H' = 1.89$) in this season versus summer ($H' = 1.36$).

Discussion

Newfoundland Marten consumed essentially all possible prey species available to them suggesting a generalist foraging strategy. These findings are in agreement with earlier studies (Buskirk and MacDonald 1984; Thompson and Colgan 1990; Martin 1994) that collectively have reported a highly diverse diet, and opportunistic use of locally available prey (Nagorsen et. al. 1989; Nagorsen et al. 1991; Martin 1994). Meadow Voles were the most frequent component of the year-round diet of Newfoundland Marten and were particularly prevalent in samples collected from early spring to late autumn. Marten commonly consume Meadow Voles in other regions (Buskirk and MacDonald 1984; Slough et al. 1989; Martin 1994; Poole and Graf 1996; Simon et al. 1999), but the frequency of occurrence found in samples from this study is the highest known to us. On the island of Newfoundland, Meadow Voles occur in coniferous forests in addition to open, grassy areas (Cameron 1958; Folinsbee et. al. 1973; Thompson and Curran 1995; Sturtevant and Bissonette 1997) thus their distribution fully overlaps with habitats used by Marten. The importance of Meadow Voles may have been more pronounced historically, since many of the prey species currently utilized by Marten were intentionally or accidentally introduced to insular Newfoundland over the last 150 years [i.e., Snowshoe Hare (Dodds 1960), Moose (Pimlott 1953), Masked Shrew (MacLeod 1960), Red Squirrel (Payne 1976), Southern Red-backed Vole (Hearn et al. 2005)], Ruffed and Spruce Grouse (Hancock 1981*). In contrast to this study, Marten on the Queen Charlotte Islands and

TABLE 2. Frequency of occurrence of food items found in 679 Marten scats and 25 stomachs in Newfoundland in winter, summer, and both seasons combined (pooled over study sites and years).

Food item	Summer n = 400	Winter n = 236	Seasons combined[a] n = 704
Meadow Vole (*Microtus pennsylvanicus*)	80	47.5	70.5
Southern Red-backed Vole (*Clethrionomys gapperi*)	0.25	0	0.1
Masked Shrew (*Sorex cinereus*)	10.5	10.6	9.9
Snowshoe Hare (*Lepus americanus*)	2.8	28	11.4
Red Squirrel (*Tamiasciurus hudsonicus*)	1.0	7.6	3.4
Unidentified mammal	4.3	10.2	4.3
Moose (*Alces alces*)/Caribou (*Rangifer tarandus*) carrion	2.5	8.9	3.6
Insects	2.0	0.4	1.4
Avian remains	7.2	10.2	8.8
Berries	15.5	0.8	9.7
Shannon Diversity Index (H′)	1.36	1.89	1.60

[a] Includes samples where the season of deposition was unknown; % frequency of occurrence values do not sum to 100% across food items.

Vancouver Island had a smaller component of small mammals in their diet and primarily foraged on birds, carrion, and salmonid fishes (Nagorsen et. al. 1989; Nagorsen et al. 1991). This ability to utilize locally available food sources reflects the opportunistic nature of Marten foraging behavior.

Snowshoe Hares were consumed throughout the year but were more prevalent in samples collected during winter. This seasonal difference may reflect a decrease in the abundance or availability of Meadow Voles associated with snow conditions and a switch to a more available prey type. The importance of Snowshoe Hares to the winter diet and overall population performance of Marten has been documented for Newfoundland marten (Bateman 1986) as well as for other northern regions (Cowan and Mackie 1950; Raine 1983; Thompson and Colgan 1987; Thompson and Colgan 1990; Poole and Graf 1996). Furthermore, Cumberland et al. (2001) documented that larger prey, including Snowshoe Hares (8.0%), grouse (12.2%) and Red Squirrels (10.8%), represented only 31% of the diet by frequency of occurrence but accounted for approximately 95% of the caloric intake by marten in New Brunswick. We suspect that the introduced Snowshoe Hare (Dodds 1983) is now a critical food resource for Newfoundland marten in winter, the most energetically stressful period annually (Thompson 1986; Buskirk et al. 1988).

In addition to preying on more Snowshoe Hares during winter, Marten increased consumption rates of carrion, Red Squirrels, birds, unidentified mammals, and Masked Shrews. This is consistent with the pattern observed by Thompson and Colgan (1990) where a wider breadth of diet was noted during winters when prey abundance was low. Masked Shrews appeared in samples for both seasons at similar frequencies but were recorded in only 2 of 22 food-habit studies reviewed by Martin (1994). Shrews have low body mass and may only be utilized in years of food scarcity. Birds are a common food source used by Marten across their range (Martin 1994) and the frequency of occurrence reported here approximated the mean reported from other studies (14.5% frequency of occurrence). Similar to Snowshoe Hares, carrion likely provided a significant source of biomass, hence total calories, during winter.

The remains of a Southern Red-backed Vole in a scat collected from southwestern Newfoundland in 1999 coincided with the first record of this species for the island (Hearn et al. 2005). Scats were not collected after 1999 in areas where Marten and Southern Red-backed Vole distributions overlap (Hearn et al. 2005), thus we were unable to assess use of this newly available prey item. Red-backed Voles are heavily utilized by American Marten elsewhere (Buskirk and MacDonald 1984; Slough et al. 1989; Thompson and Colgan 1990; Simon et al. 1999), and we anticipate increased utilization of this forest vole as its distribution and abundance expands.

Several researchers have noted fluctuating levels of prey and subsequent changes in population performance of Marten. Thompson and Colgan (1987) reported reduced population density, enlarged home ranges, and lower reproductive performance of Marten during a synchronous decline in principal prey species on their study area in northcentral Ontario. Poole and Graf (1986) suggested that the Snowshoe Hare population cycle has a significant impact on Marten populations in the northern boreal forest, and Marten harvests in Canada are historically well synchronized with Snowshoe Hare numbers (Bulmer 1974; Fryxell et al. 1999). Similarly, a decrease in small mammal numbers in central Labrador was implicated in the reduction in female to juvenile ratios and the overall harvest of Marten in the following trapping season (Simon et al. 1999). It is unknown whether Newfoundland Marten are food limited and additional research is required to understand the relationships between fluctuating prey levels and population performance for this Endangered species.

Acknowledgments

We thank various professional and technical staff, in particular Tyrone Mulrooney, John Neville, Rod Cox, Cyril Lundrigan, Bill Curran, and Joe Brazil. This study was the result of several research projects investigating the ecology of the Newfoundland Marten supported by Natural Resources Canada – Canadian Forest Service, Terra Nova National Park, the Newfoundland and Labrador Inland Fish and Wildlife Division, the Newfoundland and Labrador Forest Service, the Western Newfoundland Model Forest, Corner Brook Pulp and Paper Limited, Abitibi Consolidated Limited, and World Wildlife Fund Canada.

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Received 17 February 2004
Accepted 11 February 2005

Pollination and Breeding System of Lowbush Blueberries, *Vaccinium angustifolium* Ait. and *V. myrtilloides* Michx. (Ericacaeae), in the Boreal Forest

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Usui, Masayuki, Peter G. Kevan, and Martyn Obbard. 2005. Pollination and breeding system of lowbush blueberries, *Vaccinium angustifolium* Ait. and *V. myrtilloides* Michx. (Ericacaeae), in the boreal forest. Canadian Field-Naturalist 119(1): 48-57.

Breeding systems and pollination requirements of two wild lowbush blueberries, *Vaccinium angustifolium* and *V. myrtilloides*, in the Canadian boreal forest in the Chapleau Crown Game Preserve, Ontario, were tested. Fruit production, size and seediness were significantly higher in samples exposed to natural pollination than in those cross- or self-pollinated by hand. There were no significant differences among artificial treatments (variously hand-pollinated and bagged) except when cross-pollination (xenogamy) was done by insect pins. In *V. angustifolium,* the density of flowering varied with forest age (canopy closure). It was most in open areas and least in the sites with the most mature forest. Although fruit-set and seediness varied among forest habitats of different ages, there were no significant differences between sites in forests of different ages. Thus, pollination seems to be similarly effective no matter the age of the forest. In both species, fruit-set in 1992, which had severe June frosts, was markedly poorer than that in 1993 when the flowers suffered little frost damage. The combined number of complete and incomplete seeds from the fruit among the breeding and pollination systems tested were similar; however, the ratio of complete seeds to total seeds was greater from cross-pollinated than from self-pollinated flowers. Our observations indicate that there is little natural fruit-set without insect-mediated cross-pollination and that cross-pollination provides much better fruit and seed-set than does self-pollination.

Key Words: boreal forest, lowbush blueberries, *Vaccinium angustifolium, V. myrtilloides*, breeding system, fruit-set, seed-set, bumblebees, pollination, pollinators, Charleau, Ontario.

Lowbush blueberries (*Vaccinium angustifolium* and *V. myrtilloides*) are wide spread throughout the North American boreal forest. Their fruit is important for wildlife (Usui et al. 1994). They grow best under acidic and well-drained soils in open habitats (Eck and Childers 1966), although they persist and may thrive in clearings in darker, old forests.

Although it is generally accepted that lowbush blueberries usually depend on insects, mostly bees (Hymenoptera: Apoidea) for pollination (Eck and Childers 1966; McGregor 1976; Reader 1977; Hall et al. 1979; Morrissette et al. 1985; Mohr and Kevan 1987; Aras et al. 1996; Stubbs and Drummond 1997, 1999, 2001; Javorek et al. 2002), most research on pollination is from commercial lowbush blueberry barrens and there is little information from unmanaged habitats, completely natural stands, and especially the boreal forest (Kevan et al. 1993; Mohr and Kevan 1987).

Even in horticultural studies, the effects of self- and cross-pollination have not been thoroughly investigated. Aalders and Hall (1961), and Wood (1968) noted a high incidence of self-sterility in *V. angustifolium.* Hall and Aalders (1961) stated that about 5% of the plants they observed in Nova Scotia and New Brunswick were male-sterile and 45% produced less than a complete complement of normal pollen. Hall et al. (1966) also noted female-sterility associated with breakdown of the integument and the nucellus of the ovules. There is little published information on *V. myrtilloides*, presumably because it is of little commercial importance. It is regarded as an obligate entomophilous outcrosser (Vander Kloet and Hall 1981) and well pollinated by various bees (Morrissette et al. 1985; Aras et al. 1996). Reader (1977) examined the breeding strategies of *V. myrtilloides* in natural bogs of southern Ontario and reported that this species was self-compatible with 40% of flowers setting seed autogamously, 60–80% setting seeding set when pollination occurred between flowers of the same plant (geitonogamy), and when pollination occurred between two different plants (xenogamy), the percentage of flowers setting seed was 70%. Thus, it is possible that the breeding systems of the species are different in different parts of their ranges, as is known for other species of plants (Richards 1997). Nevertheless, in nature, pollination of most *Vaccinium* spp. by bees is essential because of the urceolate (urn-shaped) and pendulous flowers, which require that pollinators hang onto the flowers and enter them from below to obtain nectar or pollen, or both. The most effective pollinators (Javorek et al. 2002), such as bumblebees (*Bombus* spp. (Apidea)) and an array of solitary bees (Apoidea) (Finna-

more and Neary 1978) vibrate the anthers to extract pollen (vibratile or "buzz" pollination) (Buchmann 1983).

The aim of our study was to examine the effects of cross- and self-pollination on fruit-set in these two species of wild lowbush blueberries in the boreal forest and the fruiting success of *V. angustifolium* in forests of different ages.

Materials and Methods

The research was done as a part of blueberry fruit productivity project in the Chapleau Crown Game Preserve (CCGP), northern Ontario (48°N, 83°W) from 1990 to 1993. Of the 31 study sites used (Figure 1), the main one was Chaplin Number 4, studied during the flowering period (20 May to 5 July) of 1993 (Figure 2). Chaplin Number 4 site is a typical blueberry habitat with acidic, sandy soil covered by organic matter. The area was logged until 1990, burned, and the soil prepared for tree planting in 1990. Jack Pine seedlings were hand-planted in 1991 (Figure 3).

Twenty-five plots (1m × 1m) for *V. angustifolium* and 20 plots (1m × 1m) for *V. myrtilloides* were selected for experiments of the breeding system early in the blooming season in 1993 throughout Chaplin Number 4 (Figure 4). The plots were separated by at least 15 metres to assure studies on different clones (Vander Kloet 1988).

To elucidate the breeding systems of *Vaccinium angustifolium* and *V. myrtilloides* naturally occurring in the boreal forest, five treatments were set in place in each plot (1 m × 1 m) before blooming began. Sprigs of blueberries with flower buds were selected for each of the following treatments: a) Free: all flowers were

FIGURE 1. Location of Chapleau Crown Game Preserve within the boreal forest of Canada (inset) and of 31 study sites for lowbush blueberry in the area of the Ontario Ministry of Natural Resources Camp at Racine Lake.

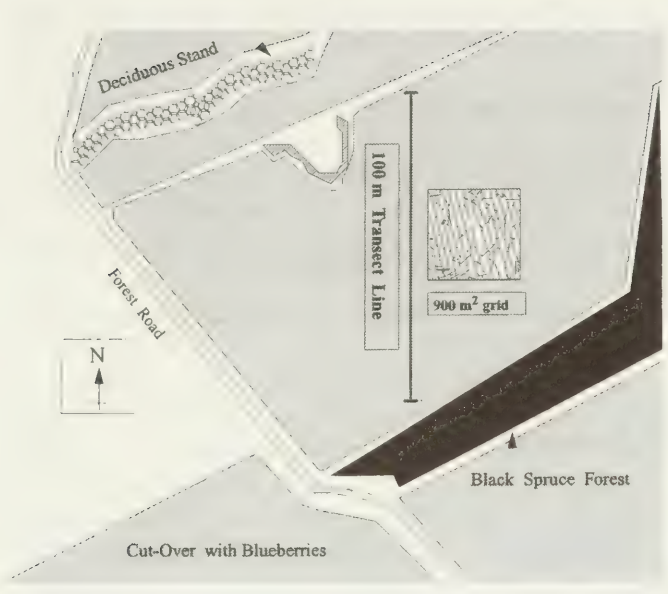

FIGURE 2. Map of the Chaplin Number of 4 (Chapleau Crown Game Preserve) study site, showing the location of the 900 m^2 study grid within the burned area (see also Figure 3).

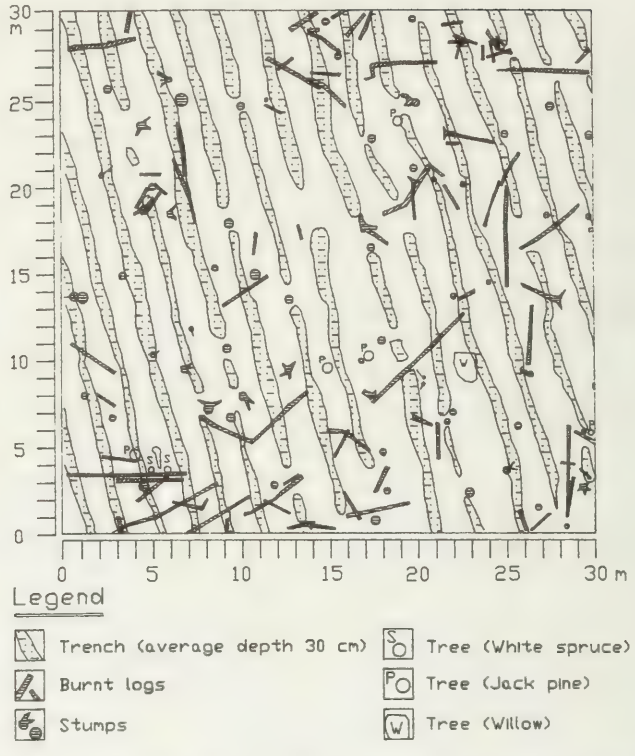

FIGURE 3. Sketch map of the 900 m^2 study grid at Chaplin Number of 4 (Chapleau Crown Game Preserve) showing trenches, burnt logs, stumps and living trees.

free to be visited by any pollinators; b) Bagged: flowers were enclosed in a white, fine mesh, bag to exclude pollinators; c) Geitonogamy: bagged (as in b) but all fresh flowers were individually pollinated by hand with pollen from other flowers of the same plant; d) Xenogamy: bagged, but all fresh flowers were pollinated individually by hand with pollen from other plants more than 15 metres away. The sprigs in each plot were marked by pink flagging tape with identification numbers at the base until the harvesting of fruit was complete (1 September).

Three methods were used to transfer pollen grains in *V. angustifolium*: toothpicks, cotton balls (approximately 2.0 cm in diameter), and Number 4 insect pins. For *V. myrtilloides*, only cotton balls were used because there were too few plants to try all methods. Anthers from fresh flower(s) were placed on a clean Petri dish and cut with toothpicks or insect pins. One torn anther was attached to a toothpick or insect pin and then touched to a stigma. Fresh, clean toothpicks or insect pins were used for each pollination. Individual corollas were touched with a small piece of cotton ball and the flower was knocked by fingers ten times onto the piece of cotton ball. The cotton ball was found to be the quickest and easiest method to use, and toothpicks the most difficult.

Fruit-set of *V. angustifolium* under different forest conditions (age of forest) was compared from 1991 to 1993. The soils in all these areas were acidic, sandy, and covered with a layer or organic duff. Fruit-set was measured in total of 100 evenly spaced plots (100 cm^2 = 10 cm × 10 cm) set along 100 m transects from the edge of, but within the forest (1 m^2 = 100 × 100 cm^2), and into the forest. The study area contained forests of all ages from newly regenerating to mature with closed canopy. All the flowers produced in each plot were counted and the fruits later harvested, counted and examined for seediness from the same plots during 1991-1993. These data were compared among forest ages and years.

During the blooming and fruiting season, some marked plants were damaged by Moose (*Alces alces*) and Black Bears (*Ursus americanus*). To reduce the effects of such damage, fresh ripened fruits from all sites, treatments, and years were hand-picked every five days. Their diameters were measured and the seeds counted.

Before the hand pollination experiments were stared, a preliminary study of pollen availability and extraction from blueberry anthers was made at the start of bloom (20 May to 4 June, 1993) to assure that pollen was being produced in sufficient quantity for our experiments. We found that individual anthers from fresh flowers (10 anthers per flower) and large buds contained from 0 to over 300 pollen grains, thus a blueberry flower may contain up to 3000 pollen grains available for removal by pollinators (Table 1). The average production of pollen grains was 166.95 ± 6.03 SE in large buds. For experimental pollinations, only fresh flowers and large buds which had had no contact with insect visitors were used as sources of pollen.

The weather from 25 May to 5 July in 1993 (the main flowering period) was cool and free from severe frosts (only 3 times were freezing temperatures, ranging -1.0 to -1.5°C, recorded at the weather screen at the Chapleau station). From 5 July until early September (the fruiting season) the weather was relatively mild

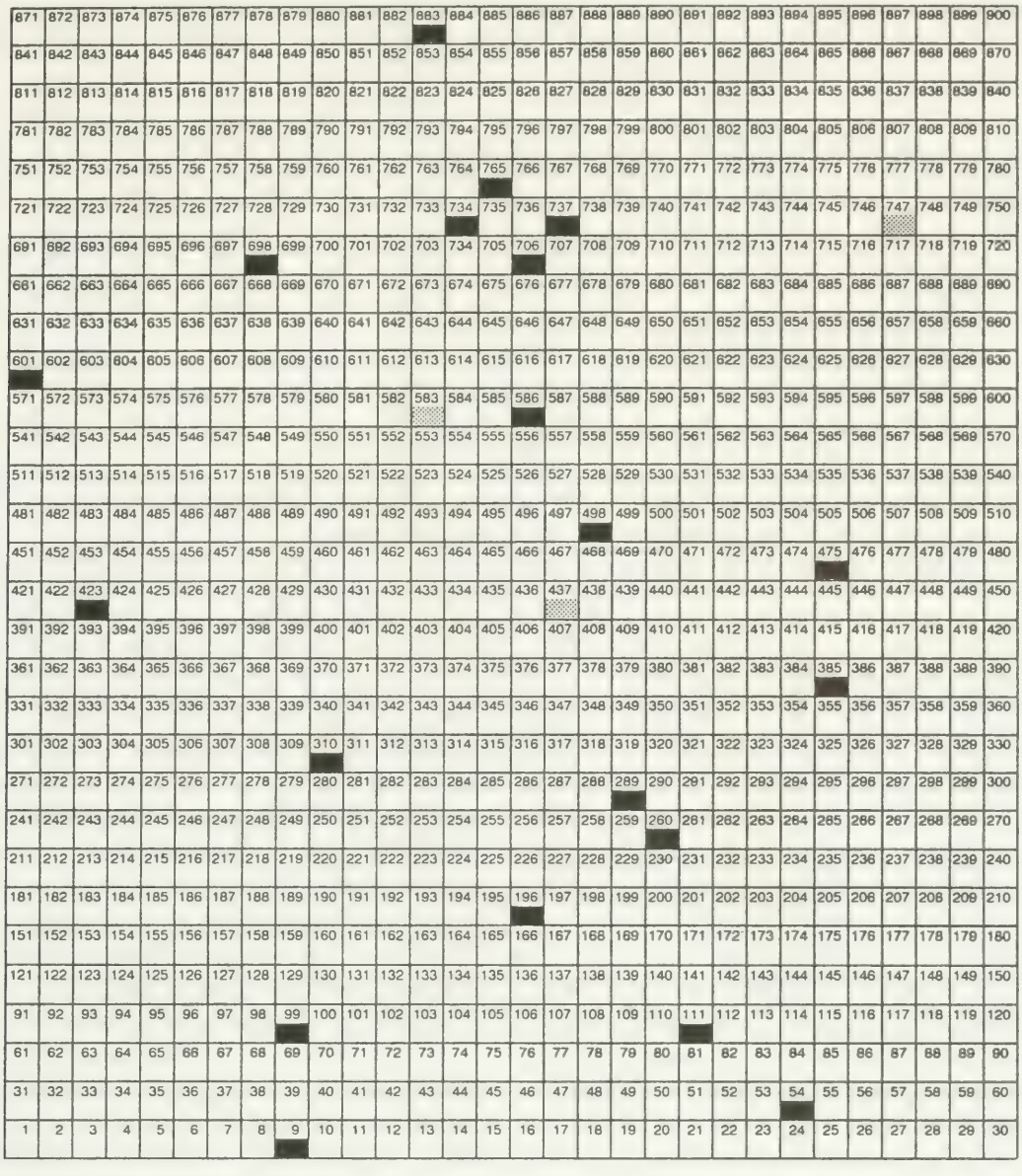

FIGURE 4. Locations of the 20 randomized plots used for pollination studies within the 900 m^2 study grid (Chapleau Crown Game Preserve).

compared to long-term average (an average monthly mean temperature was 17.2°C in July and 17.1°C in August) and wet (monthly rainfall was 106 mm in July and 54.8 mm in August). However, the weather in the spring of 1992 was cold with six occasions of below freezing temperatures, as low as -4.0 and -2.5°C, between 21 May and 22 June.

Statistical analyses of fruit-sets, seed-set, and fruit size were made. The numbers of fruits were compared in size (mm in diameter) among treatments on the two species of lowbush blueberries, respectively. Data were subjected to ANOVA and means separated by Tukey's Studentized Range Test at $P = 0.05$ level (SAS Institute 1985), or subjected to a modified ANOVA for data sets with unequal variances (Zar 1998 :187) (Toms and Almond, personal communication, see Acknowledgments). The latter approach required application of Bonferroni corrections to the critical probability value

TABLE 1. Number of pollen grains extracted from large buds of *Vaccinium angustifolium* collected from four locations in the Chapleau Crown Game Preserve. Pollen grains were extracted from one anther tube of each flower.

Range of number of approximate pollen grains	Total observations Freq.	%	Mean ± SE (Number of pollen grains)
Large bud (grains/anther)			
0	7	3.1	
10-49	8	3.6	
50-99	17	7.6	
100-199	64	28.7	
200-299	82	36.8	
< 300	45	20.2	
Total number of flowers and anthers	223		166.95 ± 6.03

TABLE 2. The comparison of fruit-set ratio among eleven pollination treatments of *V. angustifolium*.

Treatment	Number of sprigs examined	Number of sprigs with fruits (% fruit-set)	Total flowers among sprigs	Total fruits among sprigs	Mean ± SE of fruit-set %	Range of fruit-set per sprig %
Free (natural condition)	56	56 (100.0)	5570	2837	50.5 ± 2.6a*	12 to 86
Bagged (no pollination)	25	2 (8.00)	1692	2	0.1 ± 0.1c	0 to 1
Xenogamy using insect pins	8	8 (100.0)	193	40	21.3 ± 3.5a,b	5 to 33
Xenogamy using cotton balls	16	12 (75.0)	453	48	10.5 ± 2.8b	0 to 38
Xenogamy using toothpicks	16	8 (50.0)	542	25	3.4 ± 1.3b	0 to 16
Geitonogamy using insect pins	7	4 (57.1)	302	47	3.1 ± 1.5b	0 to 11
Geitonogamy using cotton balls	15	7 (46.7)	477	26	2.4 ± 0.8b	0 to 7
Geitonogamy using toothpicks	16	1 (6.3)	481	1	0.2 ± 0.2b	0 to 3
Autogamy using insect pins	8	3 (37.5)	112	12	5.3 ± 2.8b	0 to 18
Autogamy using cotton balls	16	4 (25.0)	262	4	2.1 ± 1.0b	0 to 11
Autogamy using toothpicks	16	1 (6.3)	279	1	0.4 ± 0.4b	0 to 7

*Values in a column followed by the same letter are not significantly different.

for rejection of our null hypotheses: for *V. angustifolium* $p < 0.0026$; for *V. myrtilloides* $p < 0.0071$ (Toms and Almond, personal communication).

Results

In *V. angustifolium* (Table 2), the fruit-sets, under pollination regimes were significantly different ($F_{10,97} = 128$, $P<<0.001$). Significantly the least amount of fruit-set was obtained from flowers enclosed in bags and thereafter untouched (2 fruit from 1692 flowers). The most fruit was produced by the flowers open to natural pollination. Although artificial xenogamy produced more fruit than did autogamy or geitonogamy there were no significant differences in fruit-set among hand-pollinated and bagged treatments, regardless of the method used (t ranged from 0.6 to 4.8; p ranged from 0.8 to 0.1). Our statistical analysis indicates that artificial xenogamy done with an insect pin was not significantly different from the open pollinated controls in terms of fruit-set ($t = 6.7$; $p = 0.12$). In *V. myrtilloides* (Table 3), fruit-sets under pollination regimes were significantly different ($F_{4,23} = 17$; $p << 0.001$). Again, open pollination produced more fruit than any of the other four treatments among which there were no significant differences (t ranged from 1.1 to 1.9; p ranged from 0.31 to 0.47) except for bagged and left alone, which again had markedly few fruits (6 from 1794 flowers).

In *V. angustifolium*, the fruits that developed from free pollinations had the greatest number of seeds (Table 4), but those that developed from the hand-done xenogamy had significantly fewer (ANOVA $F_{6,93} = 7.26$, $p = 0.05$), and those from hand done geitonogamy and autogamy were by far the least and were not significantly different from each other (ANOVA $F_{4,14} = 1.08$, $p = 0.05$; $F_{3,10} = 1.26$, $p = 0.05$). Fruit diameters were also affected by treatment (Table 4). Free pollinations resulted in the largest and seediest fruits (31.3 ± 5.9 SE seeds in the 12.5 mm diameter class of fruits) with the other treatments significantly different from each other and the average size of fruit being smaller (Table 4) (ANOVA $F_{7,113} = 8.20$, $p = 0.05$). The fruits from geitonogamy and xenogamy were disproportionately smaller with fewer seeds than those from free pollination. There were no significant differences in fruit size and seediness from flowers pollinated by geitonogamy and autogamy (Table 4). The few fruits from flowers bagged and left along were very small (5 mm in diameter) and seedless; they were omitted from analyses.

In comparing seediness and fruit size (in 1 mm diameter classes from 4.5 to 12.5 mm) of free pollination and xenogamy treatments on *V. angustifolium*, some regression relationships were calculated and found to be significantly different from zero (Table 4 and Figure 5). How-

TABLE 2. The comparison of fruit-set ratio among five pollination treatments of *V. angustifolium*.

Treatment	Number of sprigs examined	Number of sprigs with fruits (% fruit-set)	Total flowers among sprigs	Total fruits among sprigs	Mean ± SE of fruit-set %	Range of fruit-set per sprig %
Free (natural condition)	38	38 (100.0)	4201	2336	57.85 ± 0.3a*	11 to 86
Bagged (no pollination)	18	4 (22.2)	1794	6	0.2 ± 0.1c	0 to 1
Xenogamy using cotton balls	18	11 (61.1)	602	61	11.3 ± 4.7b	0 to 73
Geitonogamy using cotton balls	17	6 (35.3)	590	15	2.1 ± 0.9bb	0 to 9
Autogamy using cotton balls	17	4 (23.5)	209	11	5.3 ± 2.5b	0 to 31

*Values in a column followed by the same letter are not significantly different.

TABLE 4. The comparison of the complete seed production and fruit size produced from 4 pollination treatments of *V. angustifolium*.

Fruit Size	Free		Xenogamy		Geitonogamy		Autogamy	
diameter (mm)	Number of fruits	Mean ± SE of complete seeds	Number of fruits	Mean ± SE of complete seeds	Number of fruits	Mean ± SE of complete seeds	Number of fruits	Mean ± SE of complete seeds
12.5	8	31.250 ± 5.918a*						
11.5	10	26.300 ± 3.173a						
10.5	22	25.000 ± 2.764a	3	16.000 ± 8.737a				
9.5	18	22.611 ± 2.836ab	11	8.455 ± 2.436ab			4	3.750 ± 0.854a
8.5	24	13.875 ± 1.989bc	26	4.192 ± 0.433bc	1	2.000a	1	1.000a
7.5	15	10.200 ± 1.522c	31	3.355 ± 0.647c	10	1.600 ± 0.267a	7	2.286 ± 0.680a
6.5	14	10.143 ± 1.421c	15	2.133 ± 0.236c	3	1.333 ± 0.333a	2	1.500 ± 0.500a
5.5	10	9.500 ± 3.027c	8	2.000 ± 0.378c	3	0.667 ± 0.333a		
4.5			6	1.833 ± 0.654c	2	2.000 ± 1.000a		
Total	121		100		19		14	
F - values and df:		$F_{7,113} = 8.20$; $p < 0.05$		$F_{6,93} = 7.26$; $p < 0.05$		$F_{4,14} = 108$; $p < 0.05$		$F_{3,10} = 1.26$; ns

*Values in columns followed by the same letter are not significantly different

ever, no regression relationship was found for geitonogamy and autogamy mostly because of the small number of fruits (for example, $r^2 = 0.023$ and 0.039 for linear regression for each treatment respectively). The comparison regression lines between free pollination and xenogamy were significantly different from each other for all models, i.e., the regression line in free pollination is higher than that in xenogamy.

Between sites in CCGP, percent fruit-set and seediness of *V. angustifolium* did not differ significantly with different forest ages (Tables 5, 6) even though the numbers of flowers and fruits in younger forests were greater than those in the older forests (ANOVA $F_{3,6} = 0.16$ in 1991, $F_{4,11} = 0.70$ in 1992, $F_{4,7} = 0.32$ in 1993, and $F_{4,33} = 0.22$ on average for 1991 to 1993, inclusive). For example, there were 683 ripened fruits from 2108 flowers per 1 m^2 during 1991 to 1993 from patches in the young forests (A: 1 to 5 year-old after clear-cut or burned), compared to 63 ripened fruits from 190 flowers per 1 m^2 in old forest sites (E: 36 to 100 year-old forests after clear-cut), during the same years; these differences were statistically significant (ANOVA $F_{4,33} = 20.67$, for flower production, and $F_{4,33} = 5.42$, for fruit production).

Discussion

The urceotate flower structure restricts flower visitors and the most effective pollinators are large buzz-pollinating bees such as bumblebees (*Bombus* spp.) and larger andrenids (*Andrena* spp.) (Finnamore and Neary 1978; Mohr and Kevan 1987; Stubbs and Drummond 1999, 2001; Javorek et al. 2002), although other, commercially available, bees (e.g., *Apis mellifera* L. (Aras et al. 1996; Javorek et al. 2002) and *Megachile rotundata* F. (Stubbs and Drummond 1997)) may be useful. In fact, there was almost no fruit-set without manipulation of some sort on the flowers of *Vaccinium angustifolium* and *V. myrtilloides* (Table 2 and 3). Natural pollination resulted in 12 to 86% fruit-set in *V. angustifolium* and 11 to 86% fruit-set in *V. myrtilloides*. Cross-pollination by hand resulted in a fruit-set up to 38% in *V. angustifolium* and 73% in *V. myrtilloides*. From self-pollinations, fruit-set was low (less than 18% and 31% in both species, respectively).

Fruit size and seediness were greater in the natural conditions of free pollination. In the experiments, the few fruits produced by self-pollination were small with few seeds (1 to 6); more complete seed production was obtained by cross-pollination by hand (1 to 33 seeds), but even this was low by comparison by open pollination (Table 4). Eck and Childers (1966) also noted that natural pollinations produced larger berries and more seeds than did artificial cross-pollinations. Blueberry stigmata remain receptive for 5 to 8 days (Merrill 1936; Moore 1964; Wood 1962), however, fruit-set is not initiated if pollination does not occur within 3 days of anthesis (Chandler and Mason 1935). Thus, the longer period of pollination and greater amounts of pollen available under natural conditions would be expected to give rise to more, larger, seedier fruits.

Our results confirm the importance of natural xenogamy by insect pollinators in the fruit-set and seed-set of *V. angustifolium* and *V. myrtilloides* in the boreal forest of the CCGP. The small amount fruit and seed-set by experimental geitonogamy, autogamy and bagging alone may be the result of small amounts of wind-dispersed pollen (bagging alone) or accidental contamination or both (geitonogamy and autogamy).

Fruit-set ratio under natural, free pollination, was variable, ranging from 11% to 86% in *V. angustifolium* and *V. myrtilloides*. This suggests that many flowers are not pollinated or that other factors operate such as male- and female-sterility, or both (Aalders and Hall 1961; Hall and Aalders 1961; Hall et al. 1966; Reader 1977).

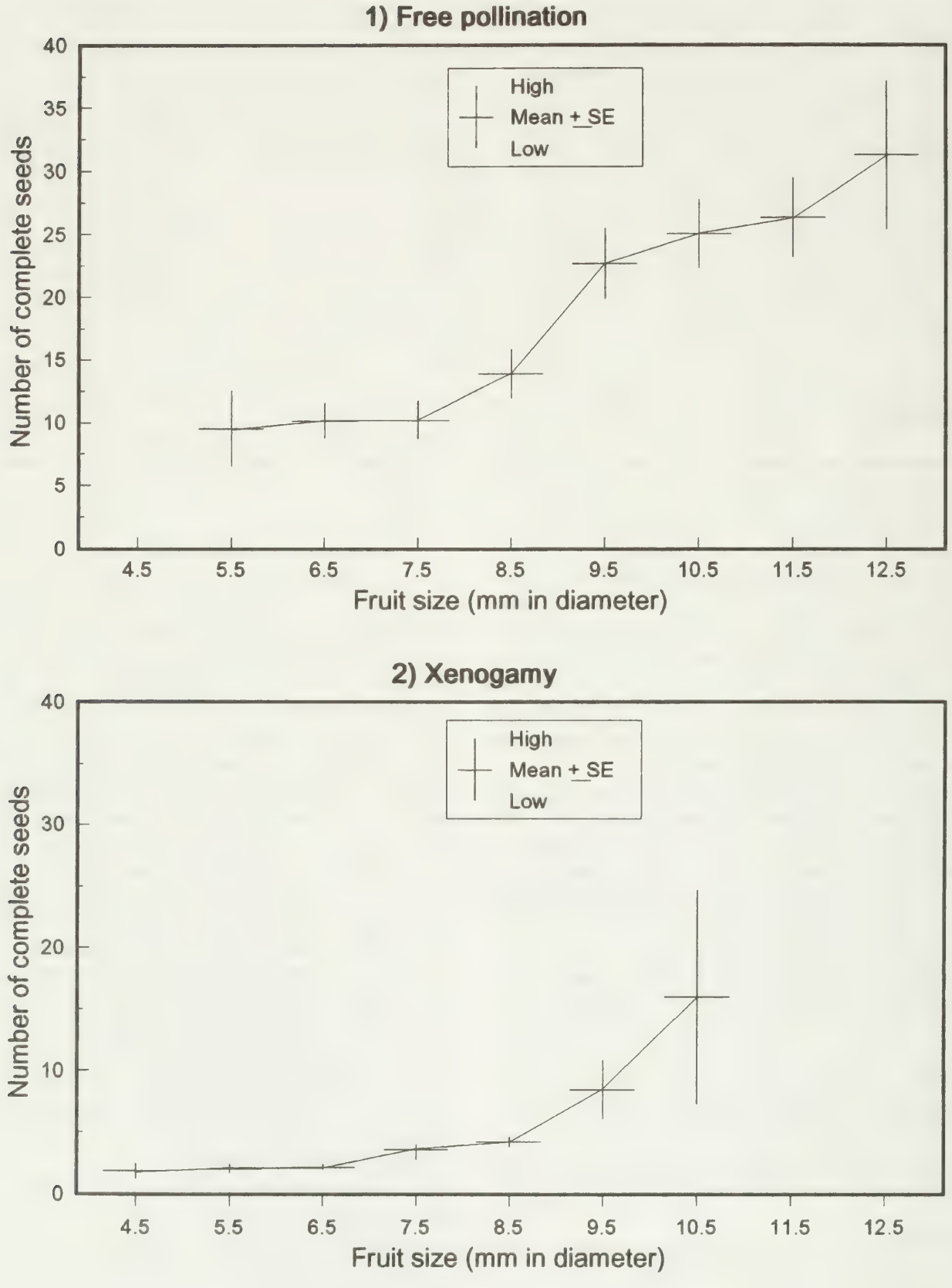

FIGURE 5. Comparison of several regression models of seediness on fruit size between free pollination and xenogamy for *Vaccinium augustifolium* in Chapleau Crown Game Preserve in 1993. 1) Free Pollination: Linear regression: r^2 = 0.3061, Y = -13 + 3.6X; Exponential regression: r^2 = 0.3297, $Y = 1.6e^{0.24X}$; Logarithmic regression: r^2 = 0.2904, Y = -46 + 29.5 (logX); Power regression: r^2 = 0.3296, $Y = 0.15X^{2.1}$, N = 121. 2) Xenogamy: Linear regression: r^2 = 0.2156, Y = -9.0 + 1.7X; Exponential regression: r^2 = 0.3436, $Y = 0.2e^{0.35X}$; Logarithmic regression: r^2 = 0.1839, Y = -19 + 11.3 (logX); Power regression: r^2 = 0.3221, $Y = 0.02X^{2.4}$, N = 100.

TABLE 5. Comparison of flower and fruit production and percent fruit-set among *V. angustifolium* in forests of different ages from 1991 to 1993. Forest age groups (years after clear-cut or burned): A (1-5); B (6-10); C (11-20); D (21-35); E (36-100).

Year and forest age group	Number of Observations (Sites)	Number of Flowers/m^2	Number of Fruits/m^2	% Fruit-set/m^2 (fruits/flowers)
		Mean ± SE	Mean ± SE	Mean ± SE
1991				
A	3	1493.0 ± 181.18a	414.67 ± 15.84a	28.67 ± 4.41a
B	3	652.0 ± 192.99b	225.00 ± 78.36 ab	33.00 ± 8.72a
C	0	—	—	—
D	3	104.7 ± 17.05b	36.67 ± 16.83b	42.33 ± 23.15a
E	1	124.0b	37.00b	30.00a
F-value and df:		$F_{3,6} = 15.57$; $p < 0.05$	$F_{3,6} = 12.30$; $p < 0.05$	$F_{3,6} = 0.16$; ns 1992
1992				
A	4	2169.5 ± 535.03a	424.00 ± 206.47a	18.00 ± 5.79a
B	2	1721.0 ± 113.00ab	352.00 ± 145.00a	21.00 ± 10.00a
C	3	962.3 ± 236.30ab	247.00 ± 85.78a	26.00 ± 5.13a
D	2	140.3 ± 20.73b	19.00 ± 4.04a	13.67 ± 2.73a
E	4	118.8 ± 42.63b	29.50 ± 14.80a	21.75 ± 4.25a
F-value and df:		$F_{4,11} = 8.52$; $p < 0.05$	$F_{4,11} = 2.14$; ns	$F_{4,11} = 0.70$; ns 1993
1993				
A	3	2642.7 ± 167.41a	1297.33 ± 157.79a	48.67 ± 3.18a
B	2	1403.5 ± 160.50b	590.00 ± 286.00ab	44.50 ± 25.50a
C	4	1053.8 ± 212.30b	410.00 ± 116.66b	38.25 ± 7.25a
D	1	415.0b		142.00b 34.00a
E	2	366.5 ± 166.50b	144.50 ± 132.50b	29.00 ± 23.00a
F-value and df:		$F_{4,7} = 17.54$; $p < 0.01$	$F_{4,7} = 7.62$; $p < 0.05$	$F_{4,7} = 0.32$; ns
Average during 1991 and 1993				
A	10	2108.5 ± 254.02a	683.20 ± 159.13a	30.40 ± 4.95 a
B	7	1172.1 ± 208.27b	365.57 ± 97.94ab	32.86 ± 7.73a
C	7	1014.6 ± 145.59b	340.14 ± 77.61ab	33.00 ± 4.99a
D	7	164.3 ± 43.52c	44.14 ± 17.89b	28.86 ± 10.38a
E	7	190.3 ± 62.53c	63.43 ± 36.58b	25.00 ± 5.72a
F-value and df		$F_{4,33} = 20.67$; $p < 0.01$	$F_{4,33} = 5.42$; ≈ 0.05	$F_{4,33} = 0.22$; ns

*Values in column followed by the same letter are not significantly different (Tukey's Studentized Range Test at $P < 0.05$).

TABLE 6. The comparison of the seediness of naturally produced fruits on *V. angustifolium* at six study sites.

Study Site	Number of fruits measured	Number of seeds/fruit Mean ± SE
Clifton Number 1	18	22.667 ± 2.894a*
Clifton Number 2	12	18.500 ± 3.115a
Clifton Number 3	49	19.265 ± 2.045a
Copperfield Number 3	9	13.222 ± 3.894a
Copperfield Number 5	3	13.615 ± 2.793a
Copperfield Number 9	20	16.150 ± 2.404a

*values in column followed by the same letter are not significantly different (Tukey's Studentized Range Test at $P < 0.05$).

In 1993, we found a few strange flowers (e.g., no pistil (one sample), short style nearly the same length of stamens (two), three-divided stigmata (one), and little or no pollen within the anthers (Table 1)), but the incidence of these aberrations is too low to explain all our records of diminished fruit and seed-set under natural pollination. Nevertheless, the fruit-sets we observed under natural conditions (means: 50.5% in *V. angustifolium* and 57.8% in *V. myrtilloides*) at Chaplin Number 4 and other study sites in 1993, indicates that the wild bee populations (or pollinator forces (Kevan et al. 1986)) were ample by comparison with those on some commercially managed lowbush blueberry barrens (an excellent commercial crop for a fruit-set of 50%, but it is usually less 10 to 20% (Karmo 1957)). Our results are different from those obtained by Reader (1977) for *V. myrtilloides*. The importance and variability in fruit-set in open pollinated flowers are demonstrated by both studies, with similar results. However, Reader's results indicate much greater capacity for self-pollination (autogamy and geitonogamy (60–80%)) in the plants he studied than we found (0–31%)). That large discrepancy suggest that the two populations, his in two bogs in southern Ontario and ours in the boreal forest, have different sexual reproductive strategies. Perhaps the relatively isolated and smaller populations in southern Ontario have adapted by having lesser reliance on entomophily in the face of less diverse guilds and smaller populations of pollinating bees; Richards (1997) provides examples of other plants with variable sexual reproductive strategies. Nevertheless, fruit-set varies

from year to year and location to location. Weather during bloom and the size of the pollinator force may be important. At CCGP, 1991 and 1993 were relatively good for blueberry production because there was little severe frosty weather to damage the flowers in June (Environment Canada 1994). However, in 1992 there were several severe June frosts that killed many flowers and buds, especially in the Clifton Number 1 study site where from 1800 flowers only 12 fruits resulted *vs.* 1094 fruits from 2540 flowers in 1993. At Clifton Number 1 the young open, forest is susceptible to severe June frosts by advective cooling (Cochran 1969a).

Our hypothesis that forest age affects fruit-set and seed-set was not validated. We found no significant differences in percent fruit-set among the forests at different ages, but did note significantly fewer flowers per unit area in older forests than in open habitats (Table 6). Pollinator populations were not as great in older forests sites as in the opened area (Usui 1994), however, we observed some shade-loving bumblebees such as *B. vagans* in the former (Usui 1994) as also noted by Heinrich (1979) in Maine. The relative paucity of flowers and paucity of pollinators seem to offset each other to allow for adequate pollination and pollinator forage. As suggested in Table 6, some locations, which have relatively larger fruits and more complete seed productions, have greater bee diversity and population.

During the blueberry flowering season at CCGP and Chaplin Number 4 study site during 1993, many bees (53 species (Usui 1994)), especially the bumblebees, *Bombus ternarius* and *B. terricola*, visited many flowers in rapid succession. They showed several flower-searching patterns; e.g., mainly toward the sun or windward in straight lines, in zig-zags, or in circles. For example, one queen of *B. ternarius* visited 1297 flowers among 55 *V. myrtilloides* plants within 30 m^2 (5 m × 6 m) in only 24.5 minutes (1600 h on 16 June) flying roughly in two large circles and re-visiting the same inflorescence of the plants (Usui 1994). Such behaviour would promote cross-pollination among different clonal plants as she transfered many different sources of viable pollen grains in a short time.

Acknowledgments

We appreciate the assistance of George Kolenosky of Ontario Ministry of Natural Resources for offering an excellent study opportunity during 1990 to 1993 in the Chapleau Crown Game Preserve. We also appreciate the assistance given by Diana Philbrick, Department of Nutritional Sciences, University of Guelph. We are especially grateful to Judith Toms and Steve Almond, University of Waterloo for statistical assistance and advice.

Financial support from NSERC (Operating/Discovery Grants to P. G. Kevan) and from OMNR Grants and funding to P. G. Kevan and M. Obbard.

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Received 13 February 2004
Accepted 27 January 2005

Productivity of Osprey, *Pandion haliaetus,* Nesting on Natural and Artificial Structures in the Kawartha Lakes, Ontario, 1991-2001

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Martin, Pamela A., Shane E. de Solla, Peter J. Ewins, Michael L. Barker. 2005. Productivity of Osprey, *Pandion haliaetus,* nesting on natural and artifical structures in the Kawartha Lakes, Ontario, 1991-2001. Canadian Field-Naturalist 119(1): 58-63.

Ospreys (*Pandion haliaetus*) declined throughout the Great Lakes basin during the 1950s to 1970s due to usage of organochlorine pesticides. Following the banning of DDT in 1972, artificial elevated nest structures were erected in the Kawartha Lakes region of south-central Ontario to aid in their recovery. As the population grew, large stumps of flooded trees, < 1 m above the surface of the water became important nesting sites, despite their propensity to flood in turbulent weather conditions. We compared the productivity of Ospreys among nest substrates and longevity of the nests in this area from 1991 to 2001. Of 260 individual nesting attempts made over the 11 years, 57% used man-made structures, primarily either quadrupod nesting platforms or utility poles. Of nests on natural substrates, stump nests accounted for 37% of total nesting attempts; elevated tree nests were relatively uncommon (6%). Productivity of stump nests was significantly greater than that of artificial or tree nests (1.48 versus 1.16 and 0.73 chicks produced per occupied nest, respectively). Nevertheless, survivorship of stump nests was less than that of platform nests after 3 years of age, as high water levels, storms or winter ice activity destroyed some of these low nests between breeding seasons. Ospreys were able to attain greater productivity in these stump nests than on man-made nesting substrates.

Key Words: Osprey, *Pandion haliaetus,* nest success, productivity, nest platforms, Ontario.

Osprey (*Pandion haliaetus*) populations in the Canadian Great Lakes basin underwent a severe decline in response to organochlorine pesticides between 1950 and 1972; however, numbers had already been depleted earlier in the century due to habitat loss through deforestation and the onset of intensive agriculture and urbanization (Ewins et al., 1995). As populations gradually recovered in the 1970s following the ban on the use of DDT, Ospreys began using a wide variety of man-made structures, such as utility poles, television antennae and navigation markers, as support for their bulky stick nests (Ewins 1996). In addition, Ospreys readily utilize custom made nesting platforms, typically located on quadrupods or tripods, 3-5 m in height, embedded in the sediment in the littoral zones of lakes, or mounted on disused utility poles on rocky islands (Ewins 1996). By the mid 1990s, 36% of occupied Osprey nests in the Great Lakes basin were on artificial structures.

In 1978, the Ontario Ministry of Natural Resources began monitoring a recovering Osprey population in the Kawartha Lakes region of south-central Ontario. During the course of the study, artificial nesting platforms were erected for their use. In 1991, the Canadian Wildlife Service initiated a study to determine if Ospreys breeding on the Great Lakes were continuing to suffer any adverse effects of contaminants, and included several lakes within the Kawartha Lakes system to provide comparative data on what was assumed to be an uncontaminated inland breeding population (Ewins et al. 1995; Martin et al. 2003). A colony of Ospreys breeding at high density in Sturgeon Lake was unexpectedly found to be more highly contaminated with PCBs than birds in other areas and monitoring there continued until 2001 (Martin et al. 2003), providing 11 seasons of data on reproduction and nest success relative to various nest substrates.

Nests in the northwestern Kawartha Lakes, including Sturgeon Lake, were primarily located either on artificial nesting platforms or on large flooded stumps which protruded less than 1 m above the surface of the water. A minority of nests was located in trees or on utility poles. Artificial nest sites of Ospreys in the Great Lakes basin have been shown to have slightly higher productivity and lower collapsing rates compared to natural nest sites (Ewins 1996). Similarly, in Saskatchewan, rates of nest success were greater on artificial structures than natural structures, though productivity was only marginally greater (Houston and Scott 1992). Productivity of Ospreys nesting on artificial sites in Baja Peninsula, Mexico, was higher than those that used natural nest structures (Castellanos and Ortega-Rubio 1995). Thus, we expected that productivity and success would be lower in nests on natural compared to artificial structures. Also, natural nests may be more transitory than artificial nests, so we contrasted longevity of nest use between natural and artificial nests.

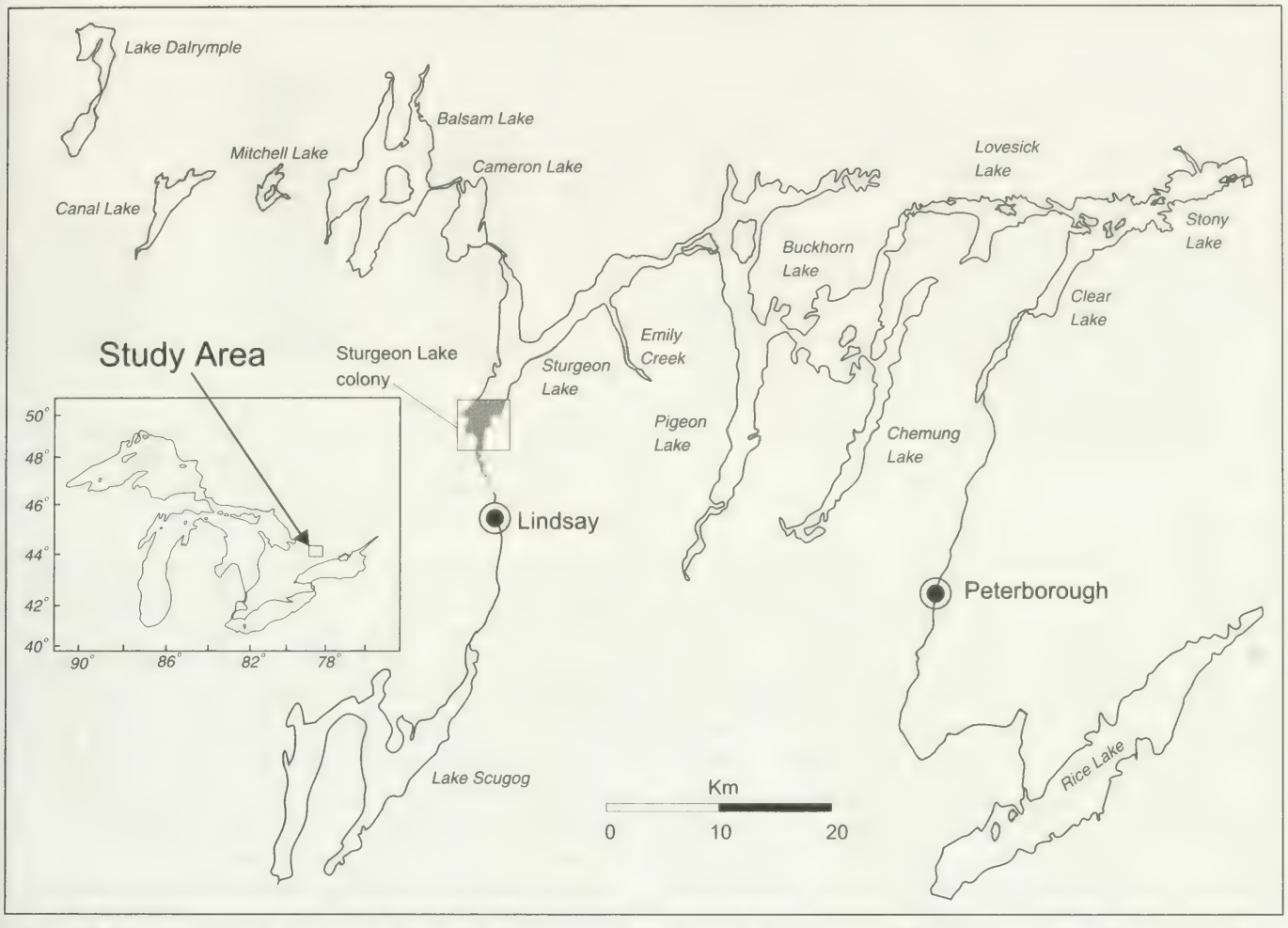

FIGURE 1. Kawartha Lakes study area indicating its position in the Great Lakes basin and the Sturgeon Lake Osprey breeding colony.

Methods and Materials

The study area was a subset of lakes within the Kawartha Lakes region in southcentral Ontario, a transitional zone bordering the Canadian Shield and the Great Lakes-St. Lawrence Lowlands ecozones. The Kawartha Lakes are a chain of 17 shallow, mainly eutrophic lakes interconnected by a series of rivers and man-made canals. The water levels are controlled in some areas through the use of dams, and the littoral regions of some lakes were flooded as a result of the construction of the Trent-Severn Waterway over the last two centuries

A group of Kawartha Lakes at the northwest end of the chain was surveyed from 1991 to 1996; these included Balsam, Canal, Dalrymple, and Mitchell Lakes and Sturgeon Lake, which included two main nesting areas: Emily Creek and a bay in the south end (Figure 1). The south end of Sturgeon Lake was the site of a fairly dense nesting "colony" of Ospreys, at which as many as 17 occupied nests occurred within a 3.5 km radius. Monitoring of the Sturgeon Lake colony continued until 2001. Because surveys at Sturgeon Lake continued an additional 5 years (1997 to 2001) beyond those of the other Kawartha Lakes (1991-1996), we tested to determine if productivity was similar before and after 1997 using a two-factor ANOVA, with nest substrate and time period (before 1997 and after 1997) as factors. There were no differences in productivity in relation to either factor or their interaction ($p > 0.05$), so further analyses included data from Sturgeon Lake for all years.

Aside from three nests in dead trees, natural nests all consisted of stumps of trees that had been felled prior to the flooding of land surrounding the original lake basin. One stump nest was later modified to include a box to improve stability, but was nevertheless considered to be a natural nest. The remaining nests were artificial and consisted of utility poles (including one unused television antenna), platforms raised on quadrupod support poles, or duckblinds. Nests were checked twice a year by boat. The first visit was in late May during incubation to count clutch size and determine occupancy. Nests on elevated man-made structures were accessed using an aluminum extension ladder. The second visit was in late June or early July to determine productivity and band chicks. Nests were classified as successful if at least one chick survived to 5 weeks old. Productivity was calculated as mean number of chicks fledged per occupied nest. Productivity and longevity of nests were compared among nest substrates using analysis of variance (ANOVA).

Frequency tables were used to compare productivity and occupancy rates, both among years and among nest substrates. Pearson χ^2 was used to test for differences in frequency. Survival analysis was used to determine if the longevity of nests, defined as the number of years that a nest was occupied, differed among nest substrates. For the survival analysis, the first year that a nest was occupied was treated as year 0. The Kaplan-Meier method (Kaplan and Meier 1958) was used to estimate the survival function, and Gehan's generalized Wilcoxon test and Cox's F test were use to contrast survival times among nest types. Statistica 5.5 was used for statistical analyses (StatSoft Incorporated 2000). Statistical significance was inferred at the $P < 0.05$ level.

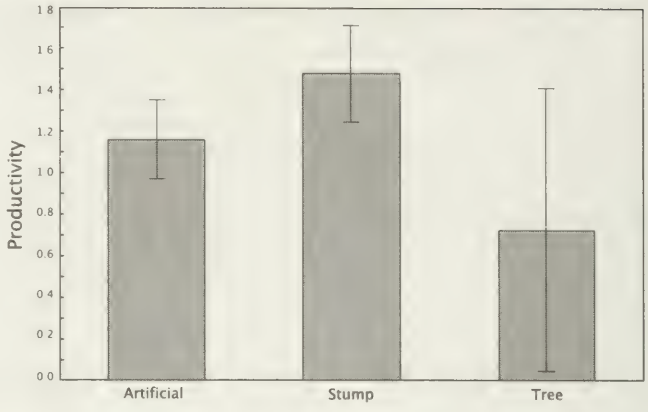

FIGURE 2. Productivity (number of chicks per active nest) of Artificial, Stump and Tree nests of Ospreys in the Kawartha Lakes region, 1991-2001.

Results

During 11 years of monitoring a northwest portion of the Kawartha Lakes region, 260 individual Osprey nesting attempts were made (Table 1). Of these, 43% were on natural substrates and 57% were on artificial structures. Of the natural substrates, overwater flooded stumps accounted for the majority, and were used in 37% of all nests; in contrast, trees provided substrate for only 6% of all nests (Table 1). The most commonly used artificial structures were the quadrupod nesting platforms (33% of all nests), followed by utility poles (20%) and duck blinds (4%).

There were no differences in productivity among the 5 nest substrates overall (Tree, Stump, Platform, Utility Pole, Duckblind: $P = 0.09$). Nevertheless, differences were found when nest substrates were compared within artificial and natural categories. Productivity was higher in Stump nests compared to Tree nests ($P = 0.05$); however, there were no differences among artificial nest substrates ($P = 0.51$). Substrates were then pooled into three groups: Stump nests, Tree nests, and Artificial nests. Productivity varied among these three nest substrates ($P = 0.04$, Figure 2), and was higher in Stump nests than either Artificial or Tree nests, having 1.48, 1.16 and 0.73 fledged chicks per occupied nest, respectively.

To test effects of nest height on productivity and nest success, we grouped nests according to height: those situated greater than 2 m above water level were High nests (Platform, Tree, and Utility pole nests), and those less than 2 m above water level as Low nests (Stump and Duck blind nests). As productivity differed among nest substrates independent of height (see above), we used a nested ANOVA, with nest height as a main effect, and nest substrate (Artificial, Stump, and Tree) as the nested factor. There were no differences in productivity between either nest height ($P = 0.50$) or substrate ($P = 0.08$) in this analysis.

There was no significant difference in nest success between Platform (58.6% successful) and Stump nests (68.5% successful; $\chi^2_{[2]} = 4.39$, $P = 0.11$). The proportion of successful and unsuccessful nests varied among years ($\chi^2_{[10]} = 20.15$, $P = 0.03$). The proportion of successful nests varied among years from 40.6% in 1995 (all lakes, 32 nests) to 91.7% in 2001 (Sturgeon Lake only, 12 nests).

Survival analysis was used to determine if longevity of nests varied among nest substrates. Because tests associated with survival analysis do not perform well at small sample sizes (StatSoft 2000), we excluded or pooled nest substrates with few observations. Thus, we compared Stump nests to Artificial nests (Utility pole and Platform). We were unable to get a good fit from several theoretical distributions. Annual survival of nests did not appear to vary between nest substrates

TABLE 1. Numbers of occupied unique nests and nest-years for Ospreys from 1991 to 2001 in the Kawartha Lakes. Nest-years was calculated by summing the numbers of years that nests of each substrate were occupied from 1991-2001.

Substrate	Number of individual nests	Nest-years (1991-2001) Number	Percent of total
Artificial			
Duck blind	5	11	4.2
Utility pole	13	52	20.0
Platform	19	85	32.7
Total	37	148	56.9
Natural			
Stump	27	96	36.9
Tree	4	16	6.2
Total	31	112	43.1

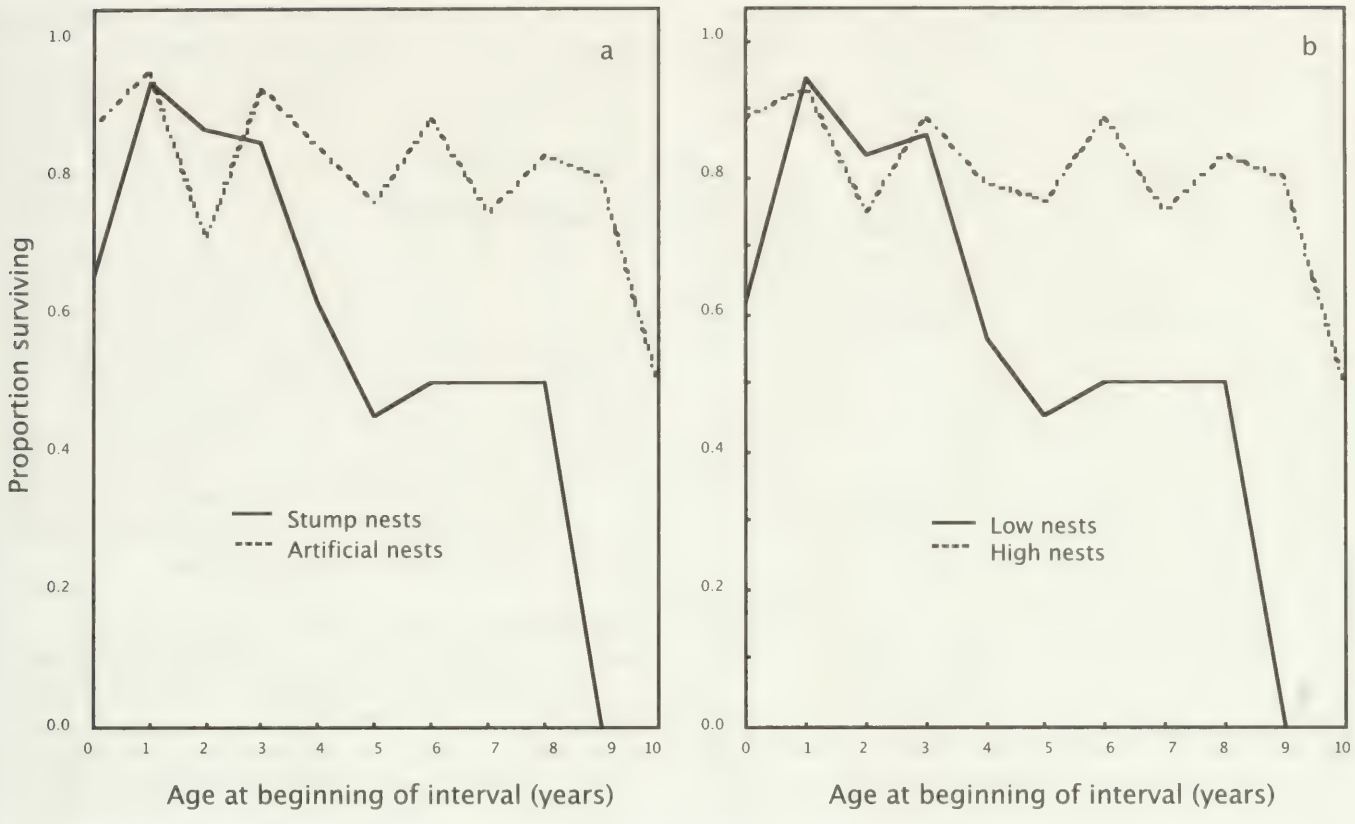

FIGURE 3. Proportion of nests surviving any given year in a) Stump and Artificial nests and b) High and Low nests.

during the first three years of their use (Gehan's Wilcoxon, P = 0.23), whereas after this age, Stump nests tended to have reduced survivorship compared to Artificial nests (Cox's F-test, $F_{[44, 44]} = 1.70$, P = 0.042; Figure 3a). Cox's F-test (also known as **log-rank**) and Gehan's Wilcoxon test emphasize the weight of later vs. earlier censored data, respectively (Fleming et al. 1987). Both Stump and Artificial nests surviving for 6 years appeared to have relatively high survivorship after that point, although the sample size was small for these older nests.

The comparison of longevity of High versus Low nests indicated that High nests had a greater longevity (Gehan's Wilcoxon Test, P = 0.02). The survivorship of High nests was largely independent of age, whereas Low nests, which were primarily Stump nests, tended to have reduced survivorship after three to five years (Figure 3b). Overall, High nests had greater survivorship than Low nests for all age classes.

Discussion

Ospreys breeding in the Kawartha Lakes region of south-central Ontario were found to nest successfully on low overwater flooded stumps. We found that, where stumps constituted the primary natural nest substrate, natural nests were more productive than nests built on artificial substrates. This contrasts with the findings of most other comparisons of natural and man-made Osprey nesting substrates. Ewins et al. (1995) found that natural nests, typically trees, were more likely to collapse and had lower productivity than artificial nest structures. Similarly, Westall (1983) found substantially higher productivity on artificial structures (1.47 chicks per occupied nest) compared to natural nests (0.69) on Sanibel Island, Florida. Postupalsky (1977) also reported that nests on artificial substrates, typically man-made nesting platforms or utility poles, had higher productivity than those on natural substrates. Witt (1996), however, found no differences in productivity from nests on man-made platforms versus trees in an Oregon population in which artificial nests comprised 35% of total active nests. In many studies in the literature however, natural nesting substrates constituted primarily trees, whereas in the current study most natural nests were constructed on low flooded stumps. Stump nests in fact were almost twice as productive as tree nests in the current study, producing a mean of 0.75 chicks per occupied nest more, annually.

Despite the greater productivity of low stump nests, we found that their longevity was not as great as that of platform or utility pole nests. Survivorship of elevated nests appeared to be more independent of age compared to low nests, largely because of the permanency of the structure – utility poles and quadrupod platforms. Low nests consisted primarily of stumps, and occasionally abandoned duck blinds, frequently in disrepair. Thus, elevated nests tended to be available every year, whereas the presence of stump nests was dependent upon sufficiently low water levels to prevent flooding or their destruction by ice action over the winter. We predict that the number of stumps available at Sturgeon and other flooded lakes within

the Kawartha Lake system will decline over the years as they degrade since further flooding of forested land is not expected. At that point Ospreys may switch to tree nesting or greater use of man-made platforms or utility poles.

That Kawartha Lakes Ospreys nesting on flooded overwater stumps were successful and productive is somewhat surprising, as Ospreys frequently nest on tall structures, presumably in part to avoid depredation. However, natural nests – mostly trees – are typically on shore, whereas the stump nests in our study were surrounded by water, far (usually > 100 m) from shore. Great horned owls (*Bubo virginianus*) appeared to be an important predator of Ospreys in our study area; four nests were found with chicks depredated that were suspected to have been depredated by owls. Thus high nests may be equally or even more vulnerable than low nests to avian predators. Owl hunting patterns may emphasize forested and edge habitat, rather than over open water where the stump nests are located. Another potentially important Osprey nest predator, raccoons (*Procyon lotor*), also present a greater risk to nearshore nests, and seem reluctant to swim far to access remote overwater nests (Poole 1989). Spring storms causing extreme wave action, waves from motorboats, and sudden alterations in water levels through manipulating of dams, were occasionally suspected of flooding these low nests, resulting in their complete destruction, removal of eggs or chicks, or abandonment (de Solla et al. 2003). Disturbance of nests by humans is another potential cause of nest abandonment or failure; nests located on overwater stumps are much more vulnerable to this impact than those high in trees. The Kawartha Lakes are popular recreational lakes, yet nests in open channels most accessible to humans appeared to suffer no greater failure than those in shallower areas with difficult boat access. The greater stability and possible lower risks of depredation conferred by overwater stump nests over tree nests appeared to account for their success and greater productivity in the current study. Certainly Ospreys in other locations have a propensity to nest in other low overwater sites, with channel navigational markers being a notable example (Poole 1989).

Many long-term programs have been implemented to monitor Osprey populations and improve recruitment, largely through the construction of artificial nesting sites (Barker 1988; Ewins 1996; Witt 1996). Most man-made nest structures consist of platforms erected upon a single pole on land, or upon a tripod or quadrupod in shallow water (Ewins 1994). The high proportion of stump nests at Sturgeon Lake was due to deliberate flooding caused by damming during the construction of the Trent-Severn waterway a century ago. Based upon the results of this study, artificial stump-like structures may also be suitable for Osprey nests, as long as they are built higher than the maximum water level during floods or annual fluctuations and are sufficiently far from shore. Artificial stump nests have the potential advantages of lower cost, lower maintenance, and fewer safety issues than taller structures, and also allow for easier access by researchers to assess nest status and productivity of nests.

Acknowledgments

Funding for much of this work was supplied by The Ontario Ministry of Natural Resources and Environment Canada's Great Lakes Action Plan. M. Bacro, L. Benner and G. Barrett provided assistance in the field. We are grateful for the Kawartha Lakes Friends of the Osprey Society for logistical support and for maintaining the artificial Osprey nest platforms. We also thank the Otonabee Region Conservation Authority, the former Ontario Hydro and the present Ontario Power Generation for their cooperation.

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Received 19 November 2003
Accepted 3 February 2005

Effects of Wetland Creation on Breeding Season Bird Use in Boreal Eastern Ontario

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Locky, David A., J. Chris Davies, and Barry G. Warner. 2005. Effects of Wetland Creation on Breeding Season Bird Use in Boreal Eastern Ontario. Canadian Field-Naturalist 119(1): 64-75.

Wetland construction has been an effective means of mitigating wetland habitat losses due to agricultural and other activities. However, the type, variety, and age of the habitats created are often critical components in the success of the wetland when the aim is to enhance the bird community. Hilliardton Marsh was constructed as a series of cells between 1993 and 1997 in boreal eastern Ontario to provide waterfowl habitat. We determined habitat change and monitored breeding-season bird use before construction and one year after the last cell was constructed. Wetland construction resulted in dramatic changes to the vegetation and bird communities. The area was transformed into a variety of wetland habitats, but primarily marsh, one of the rarest wetland types in boreal Ontario. Survey stations with moderate habitat change exhibited the greatest change in bird species richness. Total species richness increased 55% from 56 to 87 species, with obligate wetland birds increasing from 3 to 26 species. Rare birds increased from 11 to 27 species, with most as obligate or facultative wetland birds, but also Peregrine Falcon (*Falco peregrinus*). Bird abundance, as measured by the number of stations where a species was observed, increased significantly for obligate wetland birds. There were no significant losses of species from any bird group, as adjacent upland habitat was preserved. This short-term study has shown that construction of new wetland habitat in boreal eastern Ontario, especially marsh, can significantly increase the numbers of breeding-season birds, including rare species. However, long-term monitoring is required to ensure sustained success of wetland construction projects for birds.

Key Words: boreal, breeding birds, constructed wetland, marsh, rare birds, upland birds, wetland birds, Ontario.

Constructing wetlands to offset lost wetlands and maintain wildlife habitat has been widespread and relatively successful in North America (Whitman 1976; Leschisin et al. 1992; Creighton et al. 1997). In Ontario, most of the initiatives have occurred in the south where wetland losses have been extensive. Wetland creation has been less common in the boreal part of the province where wetland losses have not been perceived to be important (Ritchie 1988). However, some boreal regions with glacio-lacustrine soils have seen significant numbers of wetlands lost to conversion for agriculture. One such area in northeastern Ontario is the Little Clay Belt (LCB), where many of the wetlands were drained for agriculture in the early 1900s (Davies et al. 1996).

Marshes were more extensive before settlement in the LCB and probably once supported a large population of waterfowl (Davies et al. 1996) (Figure 1). Marsh habitat is particularly critical for wetland birds and is one of the rarest wetland types in the boreal region (National Wetlands Working Group 1988). To address wetland losses in the LCB, Ducks Unlimited Canada (DU) and its partners have initiated a number of wetland creation projects, including Hilliardton Marsh in the Hilliardton Marsh Provincial Wildlife Area (HMPWA) (Figure 1). This constructed wetland is 209ha and one of the largest projects of its kind in Ontario. The wetland was created primarily for waterfowl brood-rearing habitat, and secondarily as staging habitat for waterfowl migrating to and from the Hudson Bay and James Bay lowlands (Davies et al. 1996). It was constructed between 1993 and 1997 and comprises five cells contained within 8.6 km of dikes. This site is managed by DU and water is drawn from the adjacent Blanche River.

In May and June 1993, a pre-construction inventory of the vegetation and bird communities at the Hilliardton Marsh site was commissioned by the Ontario Ministry of Natural Resources (OMNR) and DU. Results from the 1993 inventory indicated that the vegetation was predominantly upland and that only five species of wetland birds were observed on site (Davies et. al. 1996). Regionally rare birds were observed on the site and included Upland Sandpiper (for scientific names of birds see Table 3), Short-eared Owl, Eastern Meadowlark, and LeConte's Sparrow. Preliminary post-construction vegetation (Gilbert 1997) and bird surveys (Huizer and Henshaw 1997*) were completed in 1997 before the wetland was fully constructed. Results indicated that shallow water wetland and marsh habitat was created and that waterfowl and other wetland birds were attracted to the wetland (Huizer and Henshaw 1997*).

Few studies have examined the breeding bird communities in the Clay Belt of northern Ontario (Smith 1957; Erksine 1977), which is an important area from

FIGURE 1. Hilliardton Marsh with 24 wetland bird survey stations on the dikes. Inset image shows five of six control stations outside and northeast of the wetland.

the perspective of marking the northern, eastern, and southern limits of the ranges of several bird species (Smith 1957). The purpose of this study was to determine the effects on the breeding-season bird community of complete construction of Hilliardton Marsh one year after completion and relate any changes to habitat transformation. The cells were aged from one to five years at the time of the survey. Our intent was not to provide a definitive assessment of wetland construction on breeding-season birds, but to illustrate the initial impacts of wetland construction on the bird community. Our specific objectives were to: (1) quantify habitat change in area flooded for the wetland and at the survey stations, (2) compare total and bird group species richness before and after wetland construction, (3) compare total and bird group species abundance before and after wetland construction, (4) determine changes in total and bird group rare species between years, and (5) examine the relationship between degree of habitat change and bird species richness between years.

We hypothesized that post-construction bird surveys would be dominated by wetland dependent species at stations with high habitat change, whereas survey stations with little or no habitat change would continue to be dominated by upland species. Stations with moderate habitat change would have the highest number of species and abundances. We hypothesized that rare species would increase with the addition of wetland habitat and we expected no change in any variables at the control stations.

Study Area

Hilliardton Marsh Provincial Wildlife Area is 20 km north of New Liskeard, Ontario, Canada (47°46'N; 79°42'W; 190 m a.s.l.). The topography is relatively low relief and the glacio-lacustrine soils are clay-rich (Dredge and Cowan 1989), which together have contributed to poor drainage. The site lies in the greater Mid-Boreal Wetland Region where peatlands are the dominant wetland types (National Wetlands Working Group 1988) and approximately 4% is marsh (Riley 1988).

The LCB has cropland and pasture, second-growth mixed hardwood forest, and various types of natural wetlands that include mixed deciduous and coniferous swamp, fen, bog, and tall shrub swamp (Davies et al. 1996). Prior to construction, Hilliardton Marsh was agricultural land in various states of use and abandonment, with some second-growth Trembling Aspen (*Populus tremuloides*) forest. Approximately 20% of the area was shrub swamp dominated by Speckled Alder (*Alnus incana* ssp. *rugosa*) and willows (*Salix* spp.) (Davies et al.1996).

Methods

Habitat Survey

Pre-construction habitat was delineated using a site plan (Ducks Unlimited 1986*) and post-construction habitat with 1998 aerial photographs (1:5000) and field reconnaissance. Description of the wetland classes followed the Canadian Wetland Classification System (National Wetlands Working Group 1997) and vegetation communities were defined by dominant vegetation forms following the Northern Ontario Wetland Evaluation (Ontario Ministry of Natural Resources 1994). The aereal coverage for each of the vegetation communities was calculated with a light planimeter for 1993 and 1998, and the extent of habitat change after flooding was determined. Habitat change within each of the 30 200 m radius (12.6 ha) point-count stations was also calculated. All of the wetland survey stations except two contained primarily upland habitat before flooding. Habitat change was therefore considered a general indicator of new wetland habitat. Stations were classified into three categories based on percent habitat change as follows: little or no change (0-19%, 0-2.4 ha), moderate change (20-54%, 2.5-6.8 ha), and high change (55-100%, 6.9-12.56 ha).

Bird Surveys

Thirty 200 m radius avian point-count stations were established as repeatable survey points in 1993 (Huizer and Henshaw 1997) (Figure 1). Twenty-four of the wetland survey stations were placed 400 m apart (centre to centre) on the proposed wetland impoundment berms and were used to detect changes in the bird community related to wetland construction. Six control stations were located 400 m outside the dikes away from the flooding and were used to detect changes in species composition not associated with the flooding event (e.g., weather) [Inset image in Figure 1].

To provide a bird community data set comparable to that from 1993, we completed bird surveys at the same stations, during the same survey period, and for the same duration as the 1993 surveys. Different observers were used in 1993 and 1998, but the survey standardization minimized the probability of bird diversity changes between years being attributed to unequal sample effort (Elphick 1997). Stations were surveyed between sunrise and 10:00 am when there was good visibility, no precipitation, and little wind. Upon arrival at the station the surveyor faced north, waited five minutes, and then recorded all bird movements and auditory calls during a 10-minute interval (Canadian Wildlife Service 1997*). Pre-construction point-counts were conducted 22-24 May and 11-13 June 1993. Post-construction surveys were conducted 23-25 May and 18-20 June 1998. Birds were also noted outside of the survey circles in the study area during the survey period in both years to determine total species richness and composition.

Bird Groups and Species Classification

Bird species abundance (e.g., common, rare) and status (e.g., breeder, migrant) within the LCB region were determined according to a regional bird list (Temiskaming Field Naturalists 1994*) and the Northern Ontario Wetland Evaluation System (Ontario Ministry of Natural Resources 1994). Species were considered breeding on the site if there was a singing male on territory; a pair was observed, individuals were carrying food, or there was agitated behaviour (territoriality) (Huizer and Henshaw 1997*). Species recorded for counts during the May period were only considered breeding on the site if they were within their traditional breeding range, whereas species outside their known range were considered migrants. Species classified as migrants were removed from the breeding-bird data-sets in order to compare breeding-season birds within the LCB region. However, all species in the area during surveys were recorded by including birds observed outside of survey plots. The May and June bird surveys were combined to include both early and late breeding species (approximately 15 May – 15 July).

We classified bird species into five groups based on wetland/aquatic habitat dependency as determined and further modified by life history descriptions in Cadman et al. (1987) to better reflect boreal bird communities as follows:

I. Obligate Wetland (found greater than 99% in wetlands);
II. Facultative Wetland (57-99%, generally found in or near wetlands);
III. Facultative (34-56%, occurs frequently in wetlands, but wetlands are not essential);
IV. Facultative Upland (1-33%, occasional or no use of wetlands); and
V. Upland (found greater than 99% in uplands).

The assignment of species groups or rankings to species and the results of associated statistical analyses have been a matter of discussion among experts (Simberloff and Dayan 1991). In particular, assignment of scarce species to categories, however defined, may be error-prone. However, our intent in using bird groups was to consider and monitor the bird community as a whole, with minor differences in individual rankings having little impact on the final analysis (c.f. Croonquist and Brooks 1991). Bird nomenclature in this study follows the American Ornithologist Union (AOU) 7th Edition Checklist (AOU 1998), and supplements 42 (AOU 2000), 43 (AOU 2002), 44 (AOU 2003), and 45 (AOU 2004).

Data Analysis

We assumed that the point-count circles were large enough (200 m radius, 12.6 ha in area) to include all or portions of territories for many breeding-season bird species and that the total coverage was representative of all habitat types measured at Hilliardton

Marsh. The stations were 400 m apart, much farther than the minimum 250 m suggested by Freemark and Rogers (1995) and Ralph et al. (1995) to limit double counting. However, although station edges were touching and some independence in bird observations may be compromised, the temporal scale was relatively small and the change in species richness and presence at stations was of most interest to us in this study (see Bibby et al. 1993).

The calculation of bird abundance directly from point-count data is problematic (Bibby et al. 1993; Ralph et al. 1995). This is especially true with large survey circles as used in this survey, as the detectability of birds varies greatly among different habitats (Hutto et al. 1986), among bird species (Ralph et al. 1995), and distance from observers. Instead, we used the number of stations at which a species was observed each year as a proxy for species abundance (station/species/year). We assumed that if the actual abundance of a species increased, the probability that at least one bird is observed at a station would increase. Although there is potential to artificially inflate abundance due to the possibility of several stations equating the presence of only a single individual of a species, there is also a higher probability that a species will be present at a station and thus the expected number of stations at which that species is observed will also increase (Debinsky and Humphrey 1997).

Species counts were categorized by bird group and year, and by degree of habitat change and year. For statistical analysis, we assumed that bird observation stations and observations were independent of each other and utilized time-series statistical analyses (Hurlbert 1984). Wilcoxon's Rank Sign tests were used, as the untransformed and transformed data failed Levene's Test of Equality (SPSS Inc. 2002). This test was used to determine significant changes in mean numbers of total species and species/station for the wetland stations and control stations, changes between years for number of stations/species, a proxy for abundance, and changes between years of species/station by low, moderate, and high habitat change. The McNemar Test for Significance of Changes (Conover 1980) was used to test for the significance of between-year (1993, 1998) changes in the number of stations at which a particular species was observed. All data analyses were completed using SPSS ver. 11.5.1 (SPSS Inc. 2002), except for the McNemar Test which was programmed using Microsoft Excel®.

This study was somewhat constrained by the survey design used for the original 1993 study, and presented a number of limitations on the interpretation of our results. The Canadian Wildlife Service point count survey protocol was not specifically designed for open wetlands, for which the employment of broadcast bird calls to illicit responses from more secretive wetland birds is often used; wetland birds are often less evenly distributed than upland species, increasing the difficulty of sampling efforts (Bell et al. 1973). Because only two survey stations were not peripheral (i.e., did not include edge), diversity may be unrepresentatively high for wetland birds, and under sampled in other stations (see Erskine 1977). The use of six control stations may not be enough to accurately detect changes, as even if habitats were uniform, changes detected may not be truly representative for the area. With respect to the May count dates in low boreal habitats, some insectivorous birds may be under-represented due to not having returned in breeding numbers. Additionally, some of the rare species may be vagrants outside of their normal breeding range. Despite these limitations, we feel that the data contributes much needed information on not only breeding season birds in the Clay Belt where there have been few studies, but on the effects to birds of creating rare wetland habitat in a region with high wetland losses.

Results

Habitat Change

Habitat change was dramatic after the construction of Hilliardton Marsh. The agricultural fields that encompassed 71% of the site (145 ha) were largely submerged and all of the Trembling Aspen forest was flooded (13% or 27 ha) (Table 1). The new wetland consisted of 54% marsh (112 ha), wetland with shallow water and dominated by emergent aquatic graminiods, 29% deciduous swamp (61 ha), wooded wetland dominated by either trees or shrubs, and 13% shallow water wetland (27 ha), wetland with standing or flowing water less than 2 m in mid-summer, and dominated by floating aquatic macrophytes (National Wetlands Working Group 1997). Aerial photographs taken in 1998 indicated that a large proportion of the marsh exhibited hemi-marsh habitat (50:50 open water/vegetation), which is attractive to aquatic birds (Weller 1994).

Habitat change at the survey stations was also significant, with four stations in the high change category (55-100%), 20 stations in the moderate change category (20-54%), and the six control stations in little/no change category (0-19%). Fifteen of the 24 stations that were flooded as a result of wetland construction exhibited habitat change of at least 50%.

Total Bird Species Richness

After wetland construction the total bird species richness on site increased 34% from 72 species in 1993 to 109 species in 1998. The 109 species represent 49% of the 222 birds that are known to occur on the LCB at any time as year-round residents, migrants, breeders, or winter residents (Temiskaming Field Naturalists 1994*) (Tables 2 and 3). At the HMPWA, 56 breeding species were observed, which reflects 36% of the 156 breeding species found in the in the LCB. This number increased to 87 species in 1998, or 56% of total observed breeding species in the LCB.

TABLE 1. Summary of habitat type and area before and after construction of Hilliardton Marsh. Numbers in brackets are percent of total wetland.

	1993		1998		% Change
Habitat Type	Area	(ha)	Area	(ha)	1993-1998
Early Successional Poplar/Alder Forest	14.0	(7)	0.0	(0)	(-7)
Deciduous Woods	9.0	(4)	0.0	(0)	(-4)
Early Successional White Birch/Poplar Fores	4.0	(2)	0.0	(0)	(-2)
Active Agricultural Field	5.0	(2)	0.0	(0)	(-2)
Fallow/Hay Agricultural Field	139.5	(67)	9.0	(4)	(-63)
Alder/Willow/Poplar Swamp	37.5	(18)	34.0	(16)	(-2)
Shallow Water Wetland	0.0	(0)	27.0	(13)	(+13)
Marsh	0.0	(0)	112.0	(55)	(+54)
Dead Tree/Shrub Swamp	0.0	(0)	27.0	(13)	(+13)
Total	209.0	(100)	209.0	(100)	(0)

Survey Stations and Bird Groups

Before construction of Hilliardton Marsh in 1993, most birds observed at survey stations were upland (30%), facultative upland (25%) and facultative species (25%) (Tables 2 and 3). Only 14% were facultative wetland species and 5% were obligate wetland species. One year after wetland construction (1998), 30% of the survey station birds were obligate wetland species, with 22% each as facultative and upland species, 17% as facultative upland, and 9% as facultative wetland.

There were significant differences between years for overall richness at the wetland survey stations ($P \leq 0.001$), and the average number of species/station increased from 12.6 in 1993 to 20.7 in 1998. These differences, however, were not constant across the groups (Figure 2). Birds in three groups increased significantly in richness including obligate wetland species, 0.5 to 7.0 species/station ($P \leq 0.001$), facultative wetland species, 1.5 to 2.0 species/station ($P = 0.011$), and facultative upland species, 3.5 to 4.4 species/station ($P = 0.026$). There were no significant differences between years for overall richness or number of species/station for total or grouped birds at the control stations.

Small increases in numbers of stations/species, a proxy for abundance, were observed in all five groups (Table 3), but significant differences were only evident in the obligate wetland group ($P < 0.001$). This group increased from 0.5 to 8.0 stations/species. Regionally rare Pied-billed Grebe, American Wigeon, and Northern Shoveler had particularly high relative increases in observations between years (Table 3). The provincially rare Yellow Rail was counted at one station during the 1998 survey, but individuals were heard calling in at least two other locations within the marsh during Twenty-one species had significant differences ($P = 0.039$ to $P < 0.001$) in station counts between 1993 and 1998, most of these as increases. Twelve species (57%) were obligate wetland, two were facultative wetland, four were facultative, and three were facultative upland species. All obligate wetland species had positive changes between years. Those species with losses included Wilson's Warbler (facultative wetland) ($P = 0.002$), Alder Flycatcher (facultative) ($P = 0.012$), Ruby-crowned Kinglet (facultative) ($P = 0.008$), and Mourning Warbler (facultative) ($P = 0.039$). Red-winged Blackbirds (facultative wetland) were recorded in 23 wetland stations and one control station in 1998; there were only two station observa-

TABLE 2. Summary of bird species richness by bird group at site and survey stations with percentages (in brackets) before and after wetland construction. Comparisons with total possible species in region and possible breeders in region at the bottom. Obligate Wetland (found greater than 99% in wetlands), Facultative Wetland (57-99%, generally found in or near wetlands), Facultative (34-56%, occurs frequently in wetlands, but wetlands are not essential), Facultative Upland (1-33%, occasional or no use of wetlands), and Upland (found greater than 99% in uplands).

Bird Group	Possible in Region		Possible Breeding		Before (1993) Site		Before (1993) Survey		After (1998) Site		After (1998) Survey	
Obligate Wetland	72	(32)	40	(26)	5	(7)	3	(5)	34	(31)	26	(30)
Facultative Wetland	16	(7)	11	(7)	8	(11)	8	(14)	10	(9)	8	(9)
Facultative	30	(14)	26	(17)	16	(22)	14	(25)	20	(18)	19	(22)
Facultative Upland	33	(15)	26	(17)	16	(22)	14	(25)	20	(18)	15	(17)
Upland	71	(32)	53	(34)	27	(38)	17	(30)	25	(23)	19	(22)
Total	222	(100)	156	(100)	72	(100)	56	(100)	109	(100)	87	(100)
% of Total Possible Species in the Region						(32)		(25)		(49)		(39)
% of Possible Breeding Species in the Region						(46)		(36)		(70)		(56)

TABLE 3. Bird species observed at the site and within survey stations before and after construction of Hilliardton Marsh. Stations column lists the number of stations in which a species was observed, which is a proxy for abundance. Asterisk denotes species observed within and outside of survey stations. See text for explanation of bird groups.

Bird Species		Abun/	Bird	Before		After	
Common Name	Scientific Name	Status	Group	Site	Stations	Site	Stations
Canada Goose	*Branta canadensis*	CM	Obligate Wetland			*	3
Wood Duck	*Aix sponsa*	CB				*	6
American Wigeon	*Anas americana*	CB				*	11
American Black Duck	*Anas rubripes*	CB				*	1
Mallard Duck	*Anas platyrhynchos*	CB		*		*	16
Blue-winged Teal	*Anas discors*	C				*	14
Northern Shoveler	*Anas clypeata*	UB				*	10
Northern Pintail	*Anas acuta*	CM				*	
Green-winged Teal	*Anas crecca*	CB				*	5
Ring-necked Duck	*Aythya collaris*	CB				*	3
Common Goldeneye	*Bucephala clangula*	CB				*	8
Hooded Merganser	*Lophodytes cucullatus*	CB				*	1
Common Merganser	*Mergus merganser*	CB				*	1
Pied-billed Grebe	*Podilymbus podiceps*	CB				*	20
Horned Grebe	*Podiceps auritus*	RM				*	2
Double-crested Commorant	*Phalacrocorax auritus*	RM				*	
American Bittern	*Botaurus lentiginosus*	CB				*	12
Great Blue Heron	*Ardea herodias*	CB				*	1
Yellow Rail	*Coturnicops noveboracensis*	RB				*	1
Virginia Rail	*Rallus limicola*	RB				*	3
Sora	*Porzana carolina*	CB				*	19
American Coot	*Fulica americana*	CB				*	12
Sandhill Crane	*Grus canadensis*	RB				*	
Lesser Yellowlegs	*Tringa flavipes*	CM				*	
Spotted Sandpiper	*Actitis macularius*	CB				*	3
Wilson's Snipe	*Gallinago delicata*	CB		*	2	*	26
American Woodcock	*Scolopax minor*	CB				*	
Ring-billed Gull	*Larus delawarensis*	CB				*	1
Black Tern	*Chlidonias niger*	RB				*	3
Belted Kingfisher	*Ceryle alcyon*	CB		*		*	
Marsh Wren	*Cistothorus palustris*	RB				*	
Northern Waterthrush	*Seiurus noveboracensis*	UB		*	3	*	8
Swamp Sparrow	*Melospiza georgiana*	CB		*	9	*	20
Total in Group I; Brackets – total stations per species for group				5	3 (14)	34	26 (210)

Bird Species		Abun/	Bird	Before		After	
Common Name	Scientific Name	Status	Group	Site	Stations	Site	Stations
Upland Sandpiper	*Bartramia longicauda*	RB	Faculatative Wetland	*			
Northern Harrier	*Circus cyaneus*	CB		*	1	*	1
Great Gray Owl	*Strix nebulosa*	RB		*	1		
Yellow-bellied Flycatcher	*Empidonax flaviventris*	CB		*	4	*	4
Winter Wren	*Troglodytes troglodytes*	UB		*	2	*	1
Northern Parula Warbler	*Parula americana*	R				*	
Palm Warbler	*Dendroica palmarum*	CM				*	
Common Yellowthroat	*Geothlypis trichas*	CB		*	19	*	22
Wilson's Warbler	*Wilsonia pusilla*	CM		*	11	*	1
Le Conte's Sparrow	*Ammodramus leconteii*	RB		*	4	*	4
Red-winged Blackbird	*Agelaius phoeniceus*	CB		*	2	*	24
Brewer's Blackbird	*Euphagus cyanocephalus*	CB				*	1
Total in Group II; Brackets – total stations per species for group				9	8 (44)	10	8 (58)

tions in 1993 (Table 3). Presence of the regionally rare LeConte's Sparrow remained constant at four stations between 1993 and 1998.

Habitat Change and Bird Groups

Overall numbers of species/station increased between years in similar magnitude at stations with

TABLE 3. continued.

Bird Species		Abun/	Bird	Before		After	
Common Name	Scientific Name	Status	Group	Site	Stations	Site	Stations
Short-eared Owl	*Asio flammeus*	CB		*			
Ruby-throated hummingbird	*Archilochus colubris*	CB		*	1	*	
Alder Flycatcher	*Empidonax alnorum*	CB		*	19	*	10
Gray Jay	*Perisoreus canadensis*	CR		*	5	*	1
Common Raven	*Corvus corax*	CR		*		*	4
Tree Swallow	*Tachycineta bicolor*	CB				*	12
Cliff Swallow	*Petrochilidon pyrrhonota*	CB				*	1
Boreal Chickadee	*Poecile hudsonica*	RW				*	2
Ruby-crowned Kinglet	*Regulus calendula*	CB		*	12	*	4
Veery	*Catharus fuscescens*	CB	Facultative	*	13	*	17
Swainson's Thrush	*Catharus ustulatus*	CB		*	5	*	3
Hermit Thrush	*Catharus guttatus*	CB		*	4	*	4
Gray Catbird	*Dumetella carolinensis*	UB				*	2
Nashville Warbler	*Vermivora ruficapilla*	CB		*	18	*	15
Yellow Warbler	*Dendroica petechia*	CB		*	4	*	7
Black-throated Blue Warbler	*Dendroica caerulescens*	RB				*	1
Yellow-rumped Warbler	*Dendroica coronata*	CB		*	6	*	2
Connecticut Warbler	*Oporornis agilis*	RB		*			
Mourning Warbler	*Oporornis philadelphia*	CB		*	15	*	7
Song Sparrow	*Melospiza melodia*	CB		*	14	*	18
Lincoln's Sparrow	*Melospiza lincolnii*	CB		*	5	*	5
Bobolink	*Dolichonyx oryzivorus*	CB		*	10	*	6
Total in Group III; Brackets – total stations per species for group				17	14 (131)	20	19 (121)

Bird Species		Abun/	Bird	Before		After	
Common Name	Scientific Name	Status	Group	Site	Stations	Site	Stations
Peregrine Falcon	*Falco peregrinus*	RB				*	
Killdeer	*Charadrius vociferus*	CB		*		*	1
Northern Flicker	*Colaptes auratus*	CB		*	8	*	5
Pileated Woodpecker	*Dryocopus pileatus*	CR		*		*	4
Least Flycatcher	*Empidonax minimus*	CB		*	14	*	11
Eastern Kingbird	*Empidonax tyrannus*	CB		*	1	*	10
Warbling Vireo	*Vireo gilvus*	R				*	3
American Crow	*Corvus brachyrhynchos*	CR		*	2	*	10
Barn Swallow	*Hirundo rustica*	CB		*	1	*	2
Wood Thrush	*Hylocichla mustelina*	RB		*	1		
American Robin	*Turdus migratorius*	CB		*	19	*	25
Magnolia Warbler	*Dendroica magnolia*	CB		*	4	*	1
Black-throated Green Warbler	*Dendroica virens*	RB				*	
Black-and-white Warbler	*Mniotilta varia*	CB	Facultative Upland	*	11	*	6
Cedar Waxwing	*Bombycilla cedrorum*	CB		*	1	*	
Savannah Sparrow	*Passerculus sandwichensis*	CB		*	14	*	14
White-throated Sparrow	*Zonotrichia albicollis*	CB		*	23	*	18
Common Grackle	*Quiscalus quiscula*	CB		*	3	*	22
Baltimore Oriole	*Icterus galbula*	UB				*	2
Purple Finch	*Carpodacus purpureus*	CB		*	1	*	
White-winged Crossbill	*Loxia leucoptera*	UW				*	
Total in Group IV; Brackets – total stations per species for group				16	14 (103)	20	15 (134)

moderate habitat change (12.5 to 21.9) and high habitat change (12.3 to 23.5), but the results were only significant for the former ($P \leq 0.001$). Stations with no habitat change had 13.3 and 14.0 species/station for each year. The high variability in the high habitat change data suggests the sample size of four was too small for significant results ($P = 0.068$). By bird group, the distribution of species was somewhat more even and less variable in stations with moderate habitat change than in the other groups. However, the results were not significant (Figure 3).

Rare Species

Twenty-seven rare species were observed on site during the 1998 survey, more than double the 11 rare species observed in 1993 (Table 4). The most notable new rare species were the nationally threatened Pere-

TABLE 3. continued.

Bird Species		Abun/	Bird	Before		After	
Common Name	Scientific Name	Status	Group	Site	Stations	Site	Stations
Ruffed Grouse	*Bonasa umbellus*	CB		*		*	1
Broad-winged Hawk	*Buteo platypterus*	V		*		*	
American Kestrel	*Falco sparverius*	CB		*		*	3
Merlin	*Falco columbarius*	CB				*	1
Mourning Dove	*Zenaida Macroura*	CR				*	
Black-billed Cuckoo	*Coccyzus erythropthalmus*	RB				*	
Great Horned Owl	*Bubo virginianus*	CR		*			
Yellow-bellied Sapsucker	*Sphyrapicus varius*	CB		*			
Downy Woodpecker	*Picoides pubescens*	CR		*	3	*	7
Hairy Woodpecker	*Picoides villosus*	CR		*	1	*	2
Eastern Wood Pewee	*Contopus virens*	UB		*			
Blue-headed Vireo	*Vireo solitarius*	RB		*	2		
Philadelphia Vireo	*Vireo philadelphicus*	CB		*	16	*	20
Red-eyed Vireo	*Vireo olivaceus*	CB		*	2	*	4
Blue Jay	*Cyanocitta cristata*	CR		*		*	3
Horned Lark	*Eremophila alpestris*	CM		*	1	*	2
Black-capped Chickadee	*Poecile atricapillus*	CR	Upland	*	6	*	3
Red-breasted Nuthatch	*Sitta canadensis*	CR		*	1	*	
Brown Thrasher	*Toxostoma rufum*	UB				*	1
European Starling	*Sturnus vulgaris*	CB		*	3	*	4
Tennessee Warbler	*Vermivora peregrina*	CB		*	4	*	2
Chestnut-sided Warbler	*Dendroica pensylvanica*	CB		*	11	*	13
Cape May Warbler	*Dendroica tigrina*	UB					
American Redstart	*Setophaga ruticilla*	CB		*	16	*	13
Ovenbird	*Seiurus aurocapillus*	CB		*	11	*	7
Chipping Sparrow	*Spizella passerina*	CB		*	1	*	
White-crowned Sparrow	*Zonotrichia leucophrys*	CM		*		*	
Northern Cardinal	*Cardinalis cardinalis*	V					
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	CB		*	1		
Eastern Meadowlark	*Sturnella magna*	VM		*		*	1
Pine Siskin	*Carduelis pinus*	CR		*		*	1
American Goldfinch	*Carduelis tristis*	CR		*	5	*	9
Evening Grosbeak	*Coccothraustes vespertinus*	CR					
House Sparrow	*Passer domesticus*	CR		*	1		
Total Group V; Brackets - total stations per species for group				27	17 (85)	25	19 (97)

Abundance and status codes: CB – common breeder, RM – rare migrant, CM – common migrant, UB – uncommon breeder, C – common, R – rare, RB – rare breeder, RW – rare in winter, VB – very rare breeder, VM – very rare migrant, UW – uncommon in winter, V – very rare, CR – common resident.

grine Falcon and four provincially significant species, including Horned Grebe, American Coot, Yellow Rail, and Black Tern. Most of the rare species observed in 1998 had some degree of wetland dependency, with 14 as obligate wetland and four as facultative wetland. In contrast, only two of the 11 rare species observed in 1993 were provincially significant: Short-eared and Great Gray Owls. Five rare species surveyed in 1993 were not observed during the post-constructions surveys and included Short-eared Owl, Upland Sandpiper, Connecticut Warbler,Wood Thrush, and Great Gray Owl (Table 4).

Discussion

Habitat Change and the Bird Community

Habitat heterogeneity can be an important element in attracting a wide variety of bird species, especially in wetlands (Creighton et al. 1997). Wetland complexes of varying water depths and flooding duration often lead to the most comprehensive array of habitat types for birds (Murkin et al. 1997). Habitat change at Hilliardton Marsh was not only dramatic but resulted in an overall increase in habitat types. In 1998, 54% of Hilliardton Marsh was marsh habitat one to five years old. Increased vegetation diversity, percent cover, and structure attract a greater diversity of birds compared to less vegetated marshes (Whitman 1976; Kantrud and Stewart 1984; Delphey and Dinsmore 1993; Weller 1994; VanRees-Siewert and Dinsmore 1996). Many edge habitats were created and these are prime habitat for many bird species (Cyr et al.1995). Where water meets land, i.e., riparian areas, insectivorous bird abundance is often the greatest (Iwata et al. 2003). Survey stations with moderate habitat change tended to have the greatest diversity of habitats, many with hemi-marsh vegetation development, and in turn had significant increases in total species richness.

TABLE. 4. Rare birds by status and bird group at Hilliardton Marsh Provincial Wildlife Area before (1993) and after wetland construction (1998). Rarity determined by Temiskaming Field Naturalists (1994*) for upland and wetland birds, Ontario Ministry of Natural Resources (1994) for wetland birds, and Environment Canada (2004*) for threatened birds. See text for explanation of bird groups.

Status	Bird Group	Species	Before	After
Threatened	Facultative Upland	Peregrine Falcon		*
Provincially Significant	Obligate Wetland	Horned Grebe		*
	Obligate Wetland	Yellow Rail		*
	Obligate Wetland	American Coot		*
	Obligate Wetland	Black Tern		*
	Facultative Wetland	Great Gray Owl	*	
	Facultative	Short-eared Owl	*	
Regionally Significant	Obligate Wetland	American Wigeon		*
	Obligate Wetland	Northern Shoveler		*
	Obligate Wetland	Pied-billed Grebe		*
	Obligate Wetland	Double-crested Cormorant		*
	Obligate Wetland	Virginia Rail		*
	Obligate Wetland	Sora		*
	Obligate Wetland	Sandhill Crane		*
	Obligate Wetland	Marsh Wren		*
	Facultative Wetland	Upland Sandpiper	*	
	Facultative Wetland	Le Conte's Sparrow	*	*
	Facultative	Connecticut Warbler	*	
	Facultative Upland	Warbling Vireo	*	*
	Facultative Upland	Wood Thrush	*	
	Upland	Horned Lark	*	*
	Upland	Eastern Meadowlark	*	*
Locally Significant	Obligate Wetland	Canada Goose		*
	Obligate Wetland	Northern Waterthrush	*	*
	Facultative Wetland	Winter Wren	*	*
	Facultative	Gray Catbird		*
	Facultative Upland	Baltimore Oriole		*
	Upland	Brown Thrasher		*

Constructed wetlands may evolve towards the ecological characteristics of natural wetlands within a few years (Sistani et al. 1999), and wetland age has been positively correlated with increases in native wetland plant species diversity and richness (Reinartz and Warne 1993). Compared to younger wetlands with less vegetation development, wetlands four years of age have been found to have higher wetland avian species richness (VanRees-Siewert and Dinsmore 1996; Wan et al. 2001). This corresponds to the average wetland cell age at Hilliardton Marsh of 3.5 years with a range of 1-5 years in 1998. Smaller areas with homogeneous stands of Cattail (*Typha latifolia*) (with some open water) are critical for attracting species such as Marsh Wren (Verner and Engelson 1970), and this rare regional breeder was first seen at Hilliardton Marsh in 1998. However, vegetation communities are dynamic and this study captured only the initial effects of wetland vegetation development on the bird community. In new impoundments, plant succession tends to advance to stable, rooted aquatic plants and rapidly increasing invertebrate populations have been found to stabilize within two years. Thus, the initial conditions that proved favourable for many species of waterbirds diminishes (Whitman 1976). Unless the vegetation communities are maintained for a diversity of habitat types by managers, the bird community at Hilliardton Marsh will continue to change, especially for obligate wetland species. For example, increased growth of Cattail between 1998 and 1999 was documented and would attract certain birds; e.g., Marsh Wren and Red-Winged Blackbird, but displace others that favour more open habitats, e.g., diving ducks. Wooded wetland habitats such as treed swamps are used by some waterfowl for nesting or cover (Cadman et al. 1987; Merendino et al. 1995), including Common Goldeneye, Ring-necked Duck, Hooded Merganser, and Wood Duck (Table 3). The treed swamps at Hilliardton Marsh are temporary habitat, as the dominant tree is Trembling Aspen, a non-wetland species. Although these trees were alive one year after the Hilliardton Marsh was constructed, the extended flooding would eventually kill the trees leaving a dead-tree swamp (c.f. Ontario Ministry of Natural Resources 1994). That habitat structure will eventually collapse with high water levels and inevitably become marsh or shallow water habitat that is less attractive to birds with wooded-wetland affinities.

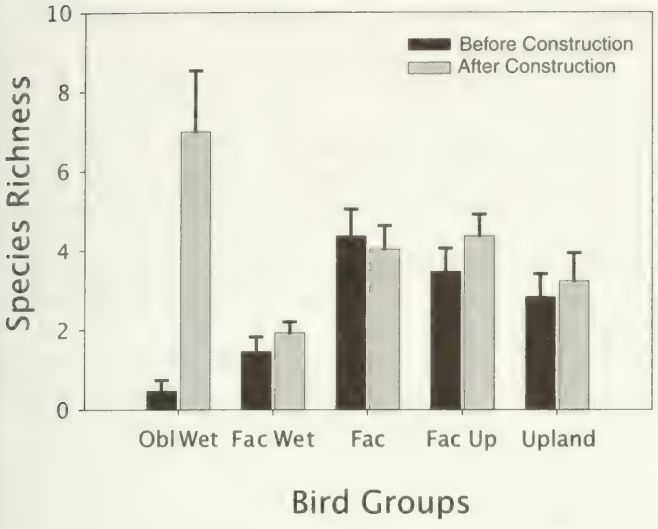

FIGURE 2. Species richness by bird group before and after wetland construction with 95% confidence interval error bars. OBl Wet = Obligate Wetland, Fac Wet = Facultative Wetland, Fac = Facultative, Fac Up = Facultative Upland. See text for explanation of bird groups.

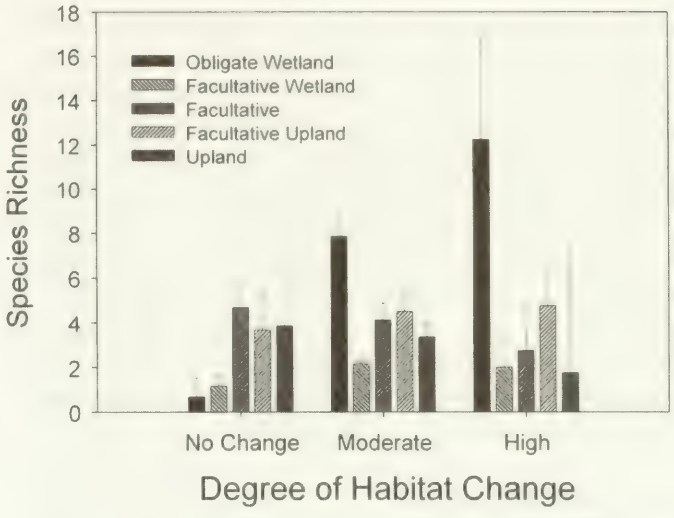

FIGURE 3. Degree of habitat change after wetland construction and bird species richness by bird groups with 95% confidence interval error bars. See text for explanation of bird groups.

Rare Habitat, Rare Species

Marsh habitat is the rarest wetland habitat in northern Ontario (National Wetlands Working Group 1988; Riley 1988). Bird species from the southern boreal region of Ontario and Quebec that inhabit open water marsh (and swamp) habitats are limited by the occurrence of these habitats (Cadman et al. 1987; Gauthier and Aubry 1996). Similar studies on the effects of restored or created wetlands have shown significant increases in numbers of obligate wetland species, numbers of individuals, and rare obligate wetland species (Dick 1993; Hickman 1994; Pollard et al. 2000). Of the rare birds observed at Hilliardton Marsh, of particular importance are those that are provincially significant. American Coot, Black Tern, and Yellow Rail are rare breeders in northern Ontario (Cadman et al. 1987). Amerian Coot and Black Tern have declined in numbers and distribution over the past two decades (Cadman et al. 1987; Austen et al. 1994), and Yellow Rails are among the most reclusive birds in Ontario (Bart et al. 1984).

It is also significant that observations and abundances of many species of rare birds did not change between years. Open, riparian habitat for the facultative wetland LeConte's Sparrow (Cadman et al. 1987) lost during wetland construction was recreated during the same process in different locations. Open, prairie-type habitat that is suitable for Horned Lark and Eastern Meadowlark (Cadman et al. 1987) was maintained.

Additionally, some new and rare birds, mostly at the local level, were observed from the facultative, facultative upland, and upland groups during 1998. These included Warbling Vireo, Gray Catbird, Baltimore Oriole, and Brown Thrasher (Table 3). Some rare species such as Upland Sandpiper and Connecticut Warbler observed in 1993 were not observed in any of the post-construction surveys, and this could be attributable to natural variation within the bird population (Holyoak and Baillie 1996). We were reasonably confident that varying weather conditions; e.g., drought, was not a factor affecting bird species abundance between years. Long-distance migrants such as Ovenbirds and Red-eyed Vireos are often more susceptible to drought (Blake et. al. 1992); numbers recorded in the control stations were stable between years and precipitation records for the study period indicated no anomalies.

Continued monitoring of the bird community at Hilliardton Marsh would be necessary to determine long-term trends at the species level, especially for rare species. Additionally, new wetland projects run the risk of eradication of existing important habitat or have negative impacts on rare species (Keddy and Wisheu 1989; Hickman 1994). Maintaining habitat amenable to all rare species should be a high management priority at Hilliardton Marsh.

Conclusions

This study provides an initial view of the response of the bird community during the breeding season to wetland construction in a region where there have been few studies on birds. Bird diversity increased significantly in response to wetland construction, especially wetland birds. Constructed wetlands are not always successful in augmenting the bird community and the intended use and consequences must be carefully planned (Zhijun et al. 2004). The original aim of creating Hilliardton Marsh was to provide waterfowl habitat, and this and related work (Locky 1999) have shown this aim to be met. However, wetland construction has also attracted a range of non-target, non-waterfowl wetland species, while maintaining the

natural diversity of the original upland bird community, including rare species. A number of new wetland rare species were also attracted. This construction has been particularly favorable because the marsh habitat that was introduced is rare in the region. Therefore, the type of habitat being created is an important consideration when designing wetland construction projects and is also a consideration for continued management of constructed wetland systems. Like all wetlands, constructed wetlands are dynamic systems and long-term management and surveys would be required to ensure that the enduring potential of providing wetland bird habitat is maintained.

Acknowledgments

Alison Buchanan and Bruce Murphy assisted in the field and Doug Brook and Peter Davis provided helpful discussion. Valuable comments provided by A. J. Erskine, S. R. Wilkinson, M. N. Thormann, S. J. Hannon, S. E. Bayley, and an anonymous reviewer substantially improved this manuscript, and were greatly appreciated. This study was supported by the Northeast Science and Technology Unit of the Ministry of Natural Resources, Ducks Unlimited Canada, and the Natural Sciences and Engineering Research Council of Canada.

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Received 15 March 2004
Accepted 7 February 2005

Lichen Trimlines in the Peace-Athabasca Delta: Variations in Flora, Form, and Disturbance Regime

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Timoney, Kevin P., and Janet Marsh. 2005. Lichen trimlines in the Peace-Athabasca Delta: variations in flora, form, and disturbance regime. Canadian Field-Naturalist 119(1): 76-81.

Lichen trimlines are characteristic of aquatic systems where lichen-covered rocks border fluctuating water bodies. This study examined water-origin saxicolous lichen trimlines on acidic metacrystalline bedrock outcrops in the Peace-Athabasca Delta, northern Alberta, Canada. Twenty-seven species of saxicolous lichens were found in the vicinity of the trimlines. Species richness above the trimline (26 species) was almost twice that found below the trimline (14 species). Colonization lag time, differences in susceptibility to disturbance, and site influences on lichen establishment and survival might be involved in the absence of many species below trimlines. In frequently inundated areas, rock surfaces are dominated by the amphibious lichens *Staurothele fissa* and *S. drummondii*. The dominant lichen colonizer below trimlines was *Physcia caesia*. Other important colonizers below trimlines included *Phaeophyscia sciastra* and *Physcia dubia*, and on rocks fertilized by bird feces, *Xanthoria elegans*. A curious feature of the saxicolous flora was the presence of many calciphiles. Variations in trimline form and height and constituent species are related to the hydrologic and disturbance regime. Trimlines in perched basins tend to be near current water level, horizontal, and distinct, and indicate a relatively stable, infrequently flooded environment. Trimlines at open-drainage sites tend to be high above current water, wavy, and indistinct, and indicate a strongly-pulsed environment with frequent disturbances. Those at restricted-drainage basins are variable in form and height and disturbance regime.

Key Words: delta, disturbance, Peace-Athabasca, saxicols, trimline, water regime, wetland, zonation, Alberta.

Zonation of lichen communities along lake and river shores has been noted for many decades (e.g., Santesson 1939) and has been attributed to gradients in physical and ecological factors. Lichen species differ in their tolerance of immersion/desiccation, siltation, water and substrate chemistry, water and ice scouring, current velocity, substrate stability, wave splash, shade, competition with bryophytes and vascular plants, and colonization rates after disturbance (Scott 1967; Ried 1974; Rosentreter 1984; Beckelhimer and Weaks 1984, 1986; Pereira et al. 1987; Gilbert and Giavarini 1997, 2000). While naming conventions have differed, lichenologists have consistently noted four lichen zones along lakes and rivers; e.g., for British lakes, Gilbert and Giavarini (2000) used the zones "terrestrial", "upper splash", "lower splash", and "submerged", while for the lower reaches of the Salmon River, Idaho, USA, Rosentreter (1984) used the zones "extreme flood", "high flood", "normal flood", and "low water".

Saxicolous lichen trimlines are typically distinct transition zones on bedrock-lined shores, below which lichens intolerant of immersion may be scarce or absent (Timoney and Marsh 2004). Above the line, there may be a continuous lichen flora attached to the rock surface; below the line there may be dominance by amphibious lichens such as *Verrucaria* or *Staurothele* (Brodo et al. 2001). In terms of typical lichen zonation, a trimline would be located somewhere in the "upper splash" / "high flood" zone.

Worldwide, there are two fundamentally different types of lichen trimlines: those due to scouring by glacial ice and those due to aquatic disturbances (e.g., Winchester and Harrison 2000). The latter are typically due to flooding or sedimentation that results in lichen mortality, followed by a low water period that exposes the transition between living lichens and bare rock or tree bark (Hale 1984; Beckelhimer and Weaks 1984, 1986).

Saxicolous lichen trimlines are characteristic of aquatic systems where lichen-covered rocks border fluctuating water bodies, e.g., in Florida (Hale 1984), in the Geraldine Lakes area of Jasper National Park, Alberta, and at various lakes in the Boundary Waters Canoe Area, Minnesota, USA (Timoney, field observations), in New South Wales, Australia (Gregory 1976), and on Georgian Bay, Ontario (Mitchell 2002).

In this era of generally declining water levels in much of North America, lichen trimlines may be useful as datable markers of previous high water levels. The objectives of this note are to document the lichen species growing on rock near lichen trimlines in a strongly-pulsed northern wetland and to describe variations in trimline form in the context of ecological and hydrological factors.

Study Area

The study area is located in the northeast portion of the Peace-Athabasca Delta, northern Alberta. While

the delta is located within the Continental High Boreal wetland region of Canada (National Wetlands Working Group 1988), its biota and vegetation are characteristic of the Continental Prairie wetland region (Timoney 2002). Inclusive of Point Providence and the Scow Channel areas, the total area of the delta is 5168 km^2, composed of 2406 km^2 of water and 2762 km^2 of non-water. The non-water portion of the delta includes forests, shrublands, marshes, meadows, mudflats, peatlands, and bedrock knolls. The present, dominant non-aquatic vegetation of the delta includes *Carex atherodes* (Awned Sedge) and *Scolochloa festucacea* (Spangletop) marshes, *Calamagrostis canadensis* (Bluejoint Reedgrass) meadows, *Salix* (Willow) thickets and savannahs, and forests of *Populus balsamifera* (Balsam Poplar) and *Picea glauca* (White Spruce) (Timoney 2004*).

Drainage basins are classified as hydrologically "open" (connected to Lake Athabasca or to major rivers at all times); semi-restricted (connected only at times of high water); or perched (receiving water only during ice-jam floods, through local precipitation or by local drainage within their catchments). Bedrock outcrops border many of these basins and are composed primarily of Precambrian acidic metacrystalline rocks (granitic or felsic gneisses). Many of these bedrock outcrops exhibit saxicolous lichen trimlines.

Methods

Sixteen sites that represented three basin types (open, semi-restricted, and perched) were sampled from 17-21 June 2002 and from 25-29 August 2003 (Table 1, Figure 1) as part of a reconstruction of water levels by lichenometry (Marsh and Timoney 2003). Access to the sites was by boat or helicopter (Site 5 is accessible on foot). Each site consisted of a boulder outcrop that exhibited a lichen trimline. At each site, a bench mark (a galvanized nail with orange flagging) was placed on the trimline in the middle of the area that was to be surveyed. The site was plotted on an NTS 1:50000 map, from which UTM coordinates were derived. The vertical height of the lichen trimline was measured with a clinometer (used as a level) sighted on a tape measure at the water's edge. Lichen species present near the trimline were recorded or collected for later identification. Sampling focused on foliose and crustose species attached to rock below the trimline and within one vertical meter above the trimline (i.e., roughly, in the "upper splash" / "high flood" and the "terrestrial" / "extreme flood" zones). For each species, </=15 lichen thalli diameters were measured to the nearest mm. The choice of thalli was not random; we looked for the larger thalli. Site descriptions of trimline aspect, width, elevation, slope, and vegetation community were prepared and photographs were taken. We described trimline form and noted relevant site and disturbance factors. Lichen nomenclature follows Esslinger (1997*), and that for vascular plants follows Moss (1983).

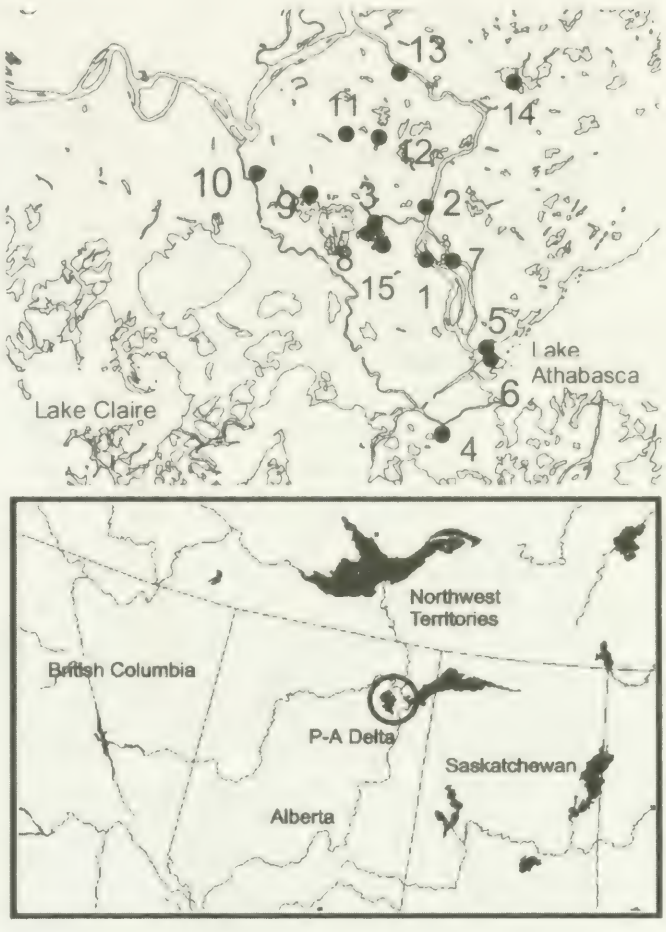

FIGURE 1. Top: Lichen study sites in the northeast sector of the Peace-Athabasca Delta (geographic center at ~111°20'W, 58°48'N). The asterisk * between Sites 3, 8 and 15 refers to "lichen observation site". Width of image from east to west is ~ 66 km. Bottom: regional context of study area.

TABLE 1. Location (decimalized latitude and longitude) and basin type of the trimline study sites.

Site	Latitude	Longitude	Basin Type
1	58.497	119.593	open
2	58.546	119.605	perched
3	58.532	119.601	semi-restricted
4	58.342	119.555	semi-restricted
5	58.420	119.574	open
6	58.408	119.571	open
7	58.497	119.593	open
8	58.522	119.599	perched
9	58.558	119.608	perched
10	58.577	119.613	semi-restricted
11	58.610	119.621	perched
12	58.608	119.620	perched
13	58.666	119.635	perched
14	58.658	119.633	semi-restricted
15	58.518	119.598	perched
*	58.521	119.599	semi-restricted

Results

Flora

The saxicolous lichen flora included at least 27 species (Table 2). Twenty-six species were found above the trimline and 14 species were found below the trimline. Only one species, *Staurothele drummondii*, appeared to be restricted to the zone below the trimline although *Staurothele fissa* was more abundant below the trimline than above it. There was a strong compositional break at the trimline. Many species common above trimlines were not found below trimlines, e.g., *Aspicilia, Dimelaena, Dermatocarpon, Lasallia*, and *Umbilicaria* and some species of *Melanelia* and *Parmelia*. Other species found above and below the trimline were far more abundant above the trimline (e.g, *Xanthoparmelia somloënsis*).

Below the trimline, rock surfaces were usually dominated by *Staurothele drummondii* or *S. fissa*, dark brown, thin crustose lichens with or without an assemblage of colonizing lichens such as *Physcia caesia*. At the majority of outcrops, the lichen community within circa one meter above the lichen trimline (the dry zone) was dominated by the foliose lichens *Xanthoparmelia somloënsis, Physcia caesia, P. phaea, Phaeophyscia sciastra, Melanelia stygia, Rhizoplaca chrysoleuca, Umbilicaria deusta* and the crustose lichens *Rhizocarpon disporum, Dimelaena oreina* and *Aspicilia caesiocinerea*. Beyond the reach of extreme high water, were a variety of lichen communities, e.g., fruticose mat formers (e.g., many *Cladonia/Cladina* species) or *Umbilicaria*-dominated areas, or vascular plant and moss communities (e.g., *Juniperus* (Juniper), *Saxifraga tricuspidata* (Prickly Saxifrage), *Amelanchier alnifolia* (Saskatoon), *Agropyron trachycaulum* (Slender Wheatgrass), *Polytrichum, Drepanocladus*, etc.) that lay beyond the scope of this study.

Variations in Trimline Form, Disturbance Regime, and Flora

Typical trimline form in open basins was wavy and indistinct; that in perched basins was level and distinct; in semi-restricted basins trimline form was variable (Table 3). Median trimline heights in open and semi-restricted basins were >2 m above current water levels, while perched basin trimline heights were <1 m above basin water levels. Median trimline elevations were similar across types while water elevations in open and semi-restricted basins were lower than in perched basins.

We observed seven variations in the trimlines.

TABLE 2. Saxicolous lichen species observed at the 16 study sites.

Species	Above Trimline	Below Trimline
Aspicilia caesiocinerea	x	
Cladina stellaris	x	
Dermatocarpon reticulatum	x	
Dimelaena oreina	x	
Lasallia pensylvanica	x	
Leproloma vouauxii	x	x
Melanelia disjuncta	x	
Melanelia sorediata	x	
Melanelia stygia	x	x
Parmelia saxatilis	x	
Parmelia sulcata	x	
Phaeophyscia sciastra	x	x
Phaeophyscia hispidula	x	
Physcia caesia	x	x
Physcia dubia	x	x
Physcia phaea	x	x
Physconia muscigena	x	x
Placidium squamulosum	x	x
Ramalina intermedia	x	
Rhizocarpon disporum	x	x
Rhizoplaca chrysoleuca	x	x
Staurothele drummondii		x
Staurothele fissa	x	x
Umbilicaria deusta	x	
Umbilicaria muehlenbergii	x	
Xanthoparmelia somloënsis	x	x
Xanthoria elegans	x	x

At Perched and Semi-Restricted Basins:

1. In most perched basins, trimlines were level and distinct with a characteristic flora of colonizing lichens below the trimline indicative of infrequent water level fluctuations (Figure 2a).
2. In two perched and semi-restricted basins, there were no colonizing lichens below a trimline located near the current standing water. The below trimline communities were dominated by amphibious *Staurothele fissa* and/or *S. drummondii*. Such sites indicate frequent small water level fluctuations. At Site 10 (Figure 2b), water levels were influenced by beavers. Dominance by lichens that favor periodic submergence and the absence of other lichens argues for periodic inundation. At Site 12, a high elevation, isolated perched basin (Figure 2c), the lowermost *Staurothele* was submerged 20 cm at time of sampling (19 June 2002).
3. At Site 11 (Figure 2d), the mid-lake outcrop served as a resting area for ducks and black terns (*Chlidonias niger*). Nitrophilic *Xanthoria elegans* and amphibious *Staurothele* were the only lichen species present below the trimline.

TABLE 3. Trimline form, height, elevation and water elevation by basin type.

Basin Type (n)	Trimline Form	Trimline Ht (median, m)*	Trimline Elevation (median, m asl)	Water Elevation (median, m asl)
open (4)	wavy, indistinct	2.20	210.83	208.61
semi-restricted (5)	variable	2.18	210.44	208.29
perched (7)	level, distinct	0.91	210.78	209.84

* above water level at time of sampling

FIGURE 2(a) A distinct and level trimline at perched basin Site 2, 79 cm above water at time of sampling. *Physcia caesia* was only colonizing lichen below the trimline. (b) A *Staurothele* community at a beaver-dam influenced semi-restricted basin (Site 10) with a trimline 40 cm above water. (c) At this isolated, bedrock upland perched basin (Site 12), above the trimline (left half of photo), dominants are *Rhizocarpon, Xanthoparmelia, Aspicilia*, and *Melanelia.* At the indistinct trimline (60 cm above water), there is a lichen-free whitish band, followed by a blackish Staurothele band, and below that, extending under water, a mixture of oxide-staining and *Staurothele* thalli. (d) A level trimline influenced by bird feces at perched basin Site 11, 102 cm above water. Above the trimline (white line) *Xanthoria elegans* dominates the cover (its orange thalli do not contrast well against the bedrock in the gray scale image); *Physcia caesia* is the only other colonizing lichen present. The dark band below the trimline is composed of *Staurothele.* (e) A high, indistinct, wavy trimline (white line near the backpack) at Site 5 on Lake Athabasca, 224 cm above water. Dominant colonizing lichen below the trimline was *Physcia caesia,* accompanied by amphibious *Staurothele* (white S) near water level. (f) A wavy and indistinct trimline at Site 7, 220 cm above water, along the Rochers River. Note the patch of flaked rock (pointer from P) in which several young lichens have established. (g) A *Leproloma vouauxii* trimline on a moist and shady vertical to overhanging gneiss at Site 4, behind a levee, 230 cm above river level. (h) A high, distinct level trimline at the semi-restricted "*"site, 218 cm above water. Note the band of lichen-free white weathered rock below the trimline, below that the blackish *Staurothele* band, and the lowest band (light gray, but reddish orange in color) of iron oxide stained rock.

At Open (and Semi-restricted) Basins and Riparian Sites:

4. Open basins were typified by high and often indistinct and wavy trimlines (Figure 2e). Colonizing lichens were present or absent, but *Staurothele* was present near the current water level. The high trimlines indicated a large drawdown, while the indistinct and wavy trimlines indicated episodic inundation or disturbance by e.g., open water and ice-jam floods, seiches, and ice scour. The disturbance regime at Lake Athabasca sites would be influenced by aspect and exposure to prevailing winds, waves, and ice scour.
5. The typical active riparian trimline was high and sometimes indistinct and wavy, indicative of active disturbance. At Site 7 on the Rochers River, patches of unweathered, lichen-free rock existed alongside rock covered by large, mature lichens and patches with young, newly-establishing lichens (Figure 2f). Colonizing lichens and *Staurothele* spp. may be present or absent at such sites.
6. Site 4 (Figure 2g), along a semi-active branch of the Quatre Fourches River not subject to wave or ice action, was a moist, shady seepage site of vertical to overhanging beds of gneissic bedrock. There was nearly complete cover of *Leproloma vouauxii* above the trimline and a sparse cover below the trimline; *Ramalina intermedia* and *Physcia caesia* were present above the trimline.
7. At two semi-restricted sites, we found no colonizing lichens below a level, high, distinct trimline on weathered granite, below which only *Staurothele* grew (Figure 2h). The absence of non-amphibious lichens indicates an unexplained impediment to lichen colonization and/or survival. The area is subject to seiches; e.g., from evening 18 June to evening 19 June 2002, local water level fell 30 cm. But seiches of a 2 m magnitude would be difficult to envision and would not be of sufficient duration to kill lichens.

Discussion

While the local bedrock is nominally acidic, near the trimlines, many lichens, mosses, and vascular plants indicate basic or circumneutral soil conditions. Some examples are, amongst the lichens — *Xanthoria elegans, Physcia caesia, Dermatocarpon reticulatum*, and *Placidium squamulosum* (Vitt et al. 1988); and mosses — *Thuidium abietinum, Tortula ruralis, Rhytidium rugosum,* and *Encalypta* sp. (Ireland 1982). Amongst the neutral to basic soil indicators in the vascular plants, *Picea glauca* dominates the forests near the trimlines.

There is no clear reason for the commonness of calciphiles on nominally acidic bedrock. We observed "dust" on rocks and saxicolous plants in the area which may be calcareous loess deposited on the outcrops rocks when nearby mudflats dry and are exposed to wind. In other situations, wave splash and wind-driven spray may wet the surfaces with delta water. Delta surface water is nutrient-rich and alkaline (Hall et al. 2003*; e.g., mean pH of lakes = 8.2, of rivers = 8.0). We found no data on the pH of local rainfall.

At many sites, the most abundant lichen below the trimline was *Physcia caesia* (a nitrophile; McCune and Geiser 1997; Brodo et al. 2001). *Physcia caesia, Xanthoparmelia somloënsis,* and *Staurothele fissa* were common pioneer species in both perched basins and open sites whereas *Phaeophyscia sciastra* colonized only perched basins. Primary sites for colonization were cracks; seepage, rough, and protected shady/moist surfaces; and dark-colored mineral bands. As birds often rest on shore-side rocks, nitrogenous bird waste may play a role in both colonization and species composition of the saxicolous communities.

Wide variations in water level, and ice-scour, along the rivers and Lake Athabasca may lead to the indistinct and wavy trimlines characteristic of open and some semi-restricted sites. At many sites, below the trimline there was a light-colored rock band situated above a reddish-orange band of oxidized iron (e.g., Figure 2c, h). This color pattern may indicate a transition from frequent reduction and oxidation due to water level fluctuations (reddish-orange) to infrequent inundation (light colored rock). Ice scour by wind- or river-driven ice blocks may scrape the rocks free of lichens, especially foliose species that are not appressed to the rock. The chaotic piling of ice blocks characteristic of break-up might contribute to the irregularity of the trimlines on open drainage sites. Flaking of the bedrock, perhaps by ice-blocks pulling away from the rock, or by *in situ* formation of ice lenses, might also act to delay lichen succession.

Width of the trimline, slope, aspect, and basin type were not related to the number of species found below the trimline (Marsh and Timoney 2003*). While site factors such as aspect can be important in determining the distribution and performance of lichens (Beckelhimer and Weaks 1986; Eversman 1982), both the relatively short time for establishment and the humidity along the shores may have masked physical effects.

Gregory (1976) found double trimlines along a river in Australia. We found no double trimlines (indicative of a high flood, followed by a period of lichen establishment below the trimline, followed by a lower flood that results in a second, lower trimline). Fourteen of 16 trimline elevations fell within a narrow range of 210.26-210.92 m asl. Based on lichen thalli diameters and local growth rates, Timoney and Marsh (2004) surmised that most of the trimlines probably formed during the period 1976 to 1990. Many of the trimlines probably formed during relatively-persistent high water which followed a major 1974 ice-jam flood. The drought-prone early 1980s may have been a key time of lichen establishment below trimlines (Marsh and Timoney 2003*). The lichen data bear on the controversy surrounding the history of changing water levels in the Peace-Athabasca Delta. As the trimlines established in response to flooding that occurred after the construction of the Bennett Dam, the trimlines cannot be construed as pre-dam high water marks. The reverse is true—they are post-dam high water marks.

How long might trimlines persist in the absence of a subsequent rise in water level that would obliterate colonizing lichens? Thalli below trimlines might reach a mean diameter within one standard deviation of

above-trimline diameters in about 27 to 55 years of uninterrupted growth. Allowing for a lichen establishment lag time of about 6-10 years in the delta (Marsh and Timoney 2003*), trimlines there might remain visually distinct for roughly 33-65 years.

Some sites had no datable lichens (only *Staurothele*) below the trimline. Species differences in colonization rates (Gilbert and Giavarini 2000) of these relatively recent surfaces, differences in susceptibility to disturbance, and site influences on lichen establishment and survival might be involved in the absence of many species below trimlines. As sites that offer insight into lichen colonization, succession, lichenometry, water level variations, and disturbance ecology, lichen trimlines deserve more study.

Acknowledgments

Thanks to Irwin Brodo, James Case, Alan Fryday, D. J. Hill, Derek Johnson, Anne Robinson, Roger Rosentreter, Mark Seaward, and Pat Wolseley for their comments regarding lichen zonation/trimlines, lichenometry, and lichen susceptibility to immersion. BC Hydro and Wood Buffalo National Park Fort Chipewyan staff provided logistic support. Stephen Hamilton assisted with office tasks.

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Received 12 May 2004
Accepted 4 March 2005

Identification of a Marine Green Alga *Percursaria percursa* from Hypersaline Springs in the Middle of the North American Continent

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Londry, Kathleen L., Pascal H. Badiou, and Stephen E. Grasby. 2005. Identification of a marine green alga *Percursaria percursa* from hypersaline springs in the middle of the North American continent. Canadian Field-Naturalist 119(1): 82-87.

The chlorophycean alga *Percursaria percursa* (Ulvaceae, Ulvales, Chlorophyceae), typical of marine inter-tidal zones, is reported for the first time from hypersaline springs located along the north-western shore of Lake Winnipegosis in Manitoba. Although not usually found inland, *P. percursa* is the dominant member of microbial mat communities that thrive in shallow pools at the outlets of hypersaline springs.

Key Words: *Percursaria percursa*, chlorophyta, hypersaline, springs, marine algae, Manitoba.

This study was undertaken to characterise the members of microbial mat communities growing in the pools and outflow channels of hypersaline springs in North-Western Manitoba. Studies on the microbial ecology of hypersaline waters has previously been limited to marshes and standing bodies of water such as salt lakes and salt production ponds (Oren 2002), so very little is known about the microbes inhabiting flowing water sources such as springs. Stable hypersaline springs are uncommon, and well-defined springs amenable to scientific study, particularly at low temperatures, are relatively rare. However, these springs can provide important information about the survival of microbes under extreme conditions. They also provide a modern analogue for the extensive microbial mats that characterised life on Earth during the Precambrian.

The highly saline pools, marshes, and saltpans on the northern margins of Lake Winnipegosis, Manitoba, have created a unique ecosystem dominated by organisms characteristic of marine habitats (Patterson et al. 1997). The flora and fauna have been described previously, with plant species composition similar to prairie saltpans (Burchill and Kenkel 1991), and animals that included marine representatives (Chordata, Protozoa, Rotifera, and Arthropoda) (McKillop et al. 1992). The distribution of the vegetation was linked to the salt tolerance of the species (Burchill and Kenkel 1991). It has been suggested (Patterson et al. 1997) that these marine species were transported to the springs area in Manitoba by birds (including Canada Geese) from coastal areas such as Hudson Bay, 700 km northeast of this site, and the Gulf of Mexico. Colonization of the saline springs could be no sooner than the retreat of the continental ice sheet, which covered the region up until about 10 000 years ago. Patterson et al. (1997) show that a saline ecosystem has been in place since at least 5500 years ago. Colonization by marine species occurred soon thereafter (Patterson et al. 1997).

Geochemical and stable-isotope analyses indicate that spring waters originate as meteoric water (Grasby et al. 2000). There was a large influx of glacial meltwater into the underlying bedrock during the Pleistocene, which dissolved the underlying beds of halite (NaCl), sylvite (KCl) and similar salts deposited by evaporation of Devonian seawater. The retreat of ice sheets has released the waters, discharging now as saline springs (Grasby et al. 2000; Grasby and Chen 2005). There are numerous saline springs along the western shore of Lake Winnipegosis (Grasby 2000). Microbial mats have only been observed at springs in the Dawson Bay area (on the north-western shore of the lake), further west along the Red Deer River (Manitoba), as well as springs near Pelican Bay (east of Dawson Bay). These hypersaline springs flow over a saltpan of barren, iron stained surficial material (McKillop et al. 1992). The high salt concentrations severely limit plant growth in the area, and life within the springs themselves is restricted to microorganisms.

Study Site

The hypersaline springs are located along the western shore of Lake Winnipegosis in North-Western Manitoba. As shown in Figure 1, the springs are in Manitoba, just south and west of Dawson Bay in the northern extent of Lake Winnipegosis. The locations and chemistry of the spring outlets are summarised in Table 1. Water samples were collected and preserved in the field. The water was passed through a 0.45 μm filter. Samples for Fe analysis were acidified to pH <2 with ultrapure NHO_3. Samples for anion analysis were untreated. Anions were measured by ion liquid chromatography, and Fe by ICP-MS. The salinity of springs studied here, the feature that defines the springs

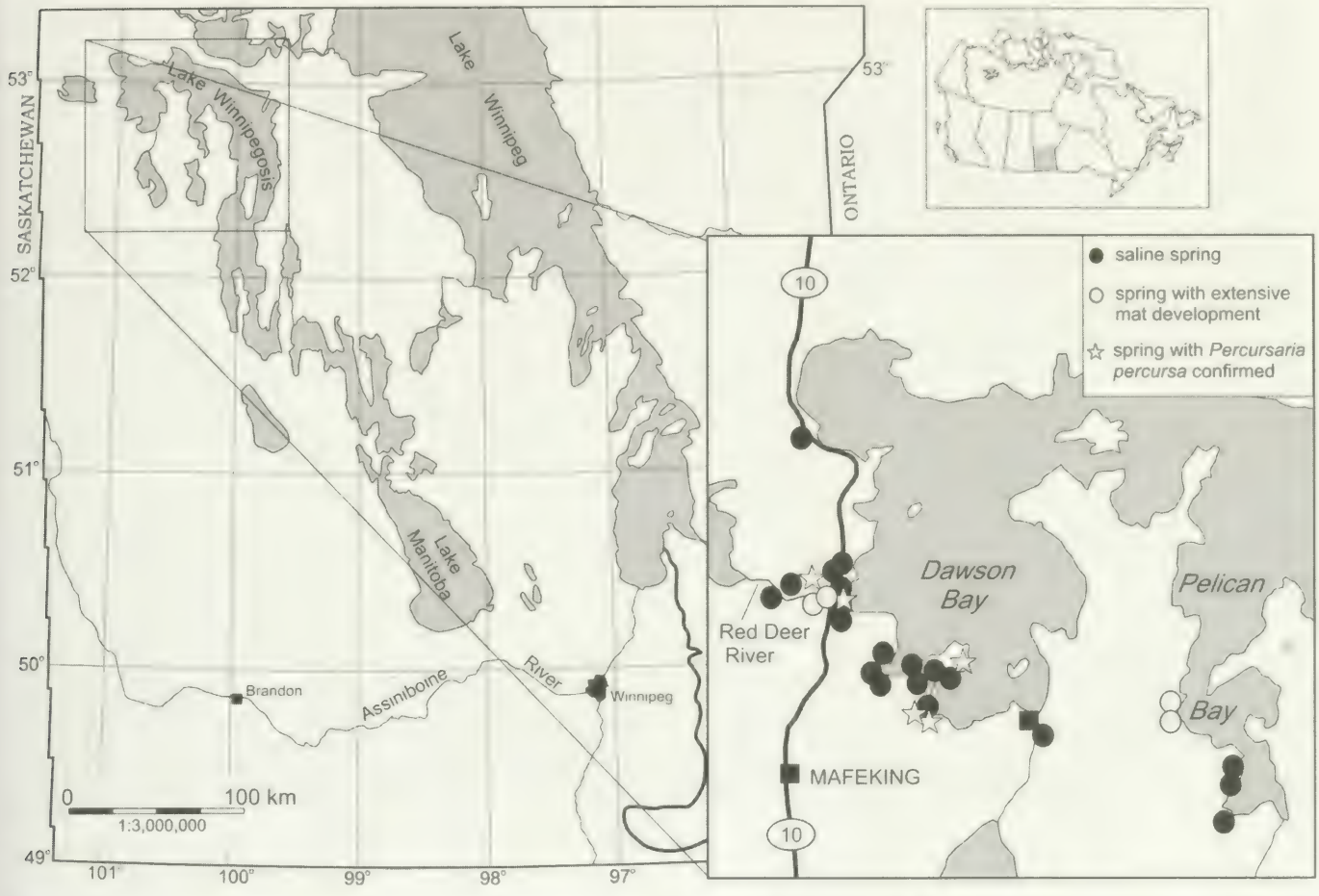

FIGURE 1. Regional map showing locations of saline springs, indicating which ones have been observed to have microbial mats of *P. percursa*.

and limits growth in these areas, ranges from below seawater to twice seawater concentrations. The salinity is mostly from NaCl (from halite), with minor differences in composition compared to typical seawater. The salt from these springs has been used historically by early settlers (Petch 1987). Chloride and sulfate concentrations in springs containing microbial mats are typically 24 to 36 g/l and 2.1 to 3.5 g/l, respectively (Table 1). Gas bubbles rising from the spring sediments were observed frequently, often becoming trapped by the overlying mat in springs with confluent growth, leading to the appearance of medium to large swellings of the mat fabric. The gas composition is dominantly N_2 (95%) with traces of CO_2 (1.8%), He (1.5%), O_2 (1.0%), Ar (0.8%), and CH_4 (0.02%) (McKillop et al. 1992), with the latter two potentially supporting microbial growth.

Each site consisted of multiple spring outlets, most of which formed pools around the origin, the oldest of which have formed raised cauldrons. Microbial mats grew on the surface and around the margins of the pools (Figure 2). There was considerable red goethite (FeO•OH) staining in areas surrounding the springs, but not in the spring sources themselves, which are dominated by calcite and quartz. Areas surrounding the springs also sometimes exhibited a characteristic "brainy" texture due to the decomposition of the algal mats beneath the evaporitic gypsum crust. The springs flow year-round and the salinity keeps some of the larger ones from freezing, even in winter (McKillops et al. 1992). Microbial mat growth was observed in freezing temperatures in the fall and spring. Samples of the microbial mats were collected in October 2001, May 2002, and August 2003. Samples were stored on ice or in a freezer (-20°C) until they were analysed by microscopy at the University of Manitoba using a Leitz Diaplan (Germany) microscope.

Results and Discussion

Organism

Percursaria percursa (C. Agardh) Bory De St. Vincent is a green alga of the order Ulvales (Ulvophyceae, Chlorophyta) that is phylogenetically related to *Ulva intestinalis* (O'Kelly et al. 2004). It forms distinct biseriate simple threads of varying breadth (Bliding 1963). The thalli are typically unbranched, up to 3 cm long, flexuous and contorted. The double row of cells is usually in exact symmetry (Figure 3), with each cell containing a single parietal band-like chloroplast similar to those seen in species of the genus *Ulothrix*. Under intense light, the chloroplast forms a narrow parietal girdle in the middle of the cell, whereas under low light levels the chloroplast becomes well developed and less band-like (Bliding 1963). The number of pyrenoids in the chloroplasts of *P. percursa* varies between one and three with most specimens typically

TABLE 1. Locations and physicochemistry of spring waters west of Lake Winnipegosis.

sample number	Latitude NAD 87	Longitude	TDS [c] mg/l	Cl mg/l	SO_4 mg/l	Fe ug/l	pH
M993013 [a]	52°48.105'	100°48.750'	64510	35700	3460	1700	6.87
M003005	52°47.977	100°49.430'	63488	35300	3220	1900	6.70
M993031	52°40.893'	100°4.798'	61637	34300	3200	1200	6.75
M993016 [a]	52°45.086'	100°52.926'	61327	33700	3170	1100	6.50
M993029 [b]	52°38.235'	100°22.120'	61015	35400	1130	1700	6.29
M993028 [b]	52°41.561'	100°21.176'	60300	33000	3170	1900	6.35
M993027 [b]	52°41.259'	100°20.988'	59404	32800	3180	1100	6.70
M993019 [b]	52°51.752'	101°08.166'	58646	32500	2970	2500	6.60
M993014 [b]	52°47.703'	100°51.817'	58197	32100	2990	2300	6.64
M003003 [a]	52°52.103'	101°04.169'	56545	31500	2780	2000	6.78
M993020 [b]	52°51.289'	101°08.159'	55861	31300	2840	2700	6.73
M003006 [b]	52°47.919'	100°53.118'	55855	31200	2770	2100	6.56
M993026 [b]	52°51.783'	101°05.392'	55626	31000	2820	<150	6.34
M983075 [a]	52°52.031'	101°03.271'	54825	31000	2800	2100	6.97
M993011 [b]	52°52.603'	101°02.886'	54543	30200	2790	<150	7.40
M993025	52°45.806'	100°52.845'	49068	27400	2600	<150	6.99
M003002 [a]	52°52.191'	101°05.563'	48522	27200	2400	1900	6.86
M993037	51°37.429'	99°58.472'	43680	22300	4590	<150	8.35
M983076 [a]	52°52.526'	101°02.359'	42405	23700	2100	3200	7.05
M003004 [b]	52°45.266'	100°53.429'	38566	21500	2090	1000	6.91
M993038	51°49.099'	99°43.493'	37208	19900	3000	<150	8.38
M993035	51°37.424'	99°56.777'	37189	18900	3690	240	7.99
M993034	51°43.390'	99°57.692'	35856	18900	3010	<150	7.96
M983077	52°54.092'	101°01.125'	32786	18500	1610	1000	6.98
M983079	52°47.205'	100°58.041'	32356	18100	1620	110	7.88
M983073	51°55.587'	100°09.384'	28857	15500	2300	2400	7.39
M993036	51°36.570'	99°51.542'	28765	14400	3360	<150	7.95
M993017	52°46.802'	100°57.852'	23733	12700	1080	340	6.48
M983074	52°00.408'	100°08.480'	22319	11700	1400	2300	7.40
M993041	52°02.191'	100°09.754'	21648	10800	2250	<150	6.94
M003007	52°57.587'	101°01.299'	21100	12100	1011	<150	6.87
M993032	51°53.731'	100°09.068'	20096	10300	1500	<150	5.98
M993021	52°43.719'	100°40.582'	18236	9970	899	<150	7.62
M993033	51°50.039'	100°07.305'	17453	8320	1580	<150	7.84
M993022	52°42.632'	100°41.958'	16946	9730	808	<150	7.10
M993039	51°48.000'	99°43.792'	14371	1400	2460	<150	7.99
M003001	51°34.591'	99°41.305'	11914	5530	1790	390	6.93
M993024	52°44.569'	100°44.862'	7189	3720	321	<150	8.28
M993015	52°46.525'	100°53.561'	5892	2850	151	<150	6.62
M993012	52°53.878'	101°02.030'	5027	2490	180	<150	7.75

[a] Hypersaline springs with *P. percursa*
[b] Hypersaline springs with algal mats, possibly *P. percursa*
[c] Total dissolved solids (TDS)

having two (Celan 1979). Although the thalli are usually biseriate, it is common to find some thalli that are uniseriate in part. Cells in the material collected from the saline springs bordering Lake Winnipegosis are a typical size (Abbott and Hollenberg 1976), between 10 – 18 µm wide and 24 – 28 µm long. The thalli are light green because of the chloroplasts, but the cells from this site are often covered by amorphous rust-coloured clusters that can impart a brown, to rust, to orange, to red colour to the mats as a whole. This has led to the illusion that these mats are dominated by red and green algae (Bezys et al. 1997; Wadien 1984), when in fact only green algae (Chlorophyta) are present.

This species is usually found with other algae, frequently forming floating entangled masses (often called green tide or sea lettuce) in upper tidepools and salt marshes. In North America, this taxon is found along the Pacific coast (Abbott and Hollenberg 1976; Setchell and Gardner 1920, Garbary et al. 1985), the Atlantic coast (South 1984; Wynne 1986), and in the Arctic (Setchell and Gardner 1920). Typically a marine organism, there is one previous report that *P. percursa* may also occur inland in environments where salt concentrations are elevated (Kornmann 1956). Although reported in many locations, this filamentous alga usually does not occur in large quantities, and is generally a minor contributor to blooms dominated by closely-related species of *Cladophora* and *Enteromorpha* (Hayden and Waaland 2002; Setchell and Gardner 1920; Taylor et al. 2001). In the hypersaline springs

FIGURE 2. Photograph of a hypersaline spring containing extensive mats of *P. percursa*. A 15 cm tent peg inserted beside the spring is included for scale.

near Lake Winnipegosis, it was by far the dominant organism, associated with various pennate diatoms and cyanobacteria (including members of the Oscillatoriaceae) (unpublished data) but not other filamentous green algae.

Habitat and distribution

There are numerous saline springs along the western shore of Lake Winnipegosis (Grasby 2000; Bezys et al. 1997; McKillop et al. 1992) as well as in north-eastern Alberta (Grasby and Chen 2005), however, prolific growth of *P. percursa* has only been confirmed at the Dawson Bay salt springs located on the north-western shore of the lake. Similar algal growths have been observed at other sites west of Pelican Bay and south of Red Deer River, but detailed analyses have not been done to confirm *P. percursa*. Salinity at these sites is typically greater than that of the springs located further south in Manitoba, and this may explain the dominance of *P. percursa*. The salinity of the springs is thought to be increasing over time (Patterson et al. 1997), and although the full range salinity tolerance is unknown, it does not seem to be limiting growth of this organism, but rather promoting it. *P. percursa* can grow in diluted seawater over a range of 0-34 PSU (practical salinity units), with an optimum of 24 PSU (Taylor et al. 2001), but tolerance above seawater has not been tested. *P. percursa* has a broad tolerance to environmental conditions of irradiance (9-175 µmol m^{-2} s^{-1}) and temperature (at least 10-30°C), as well as

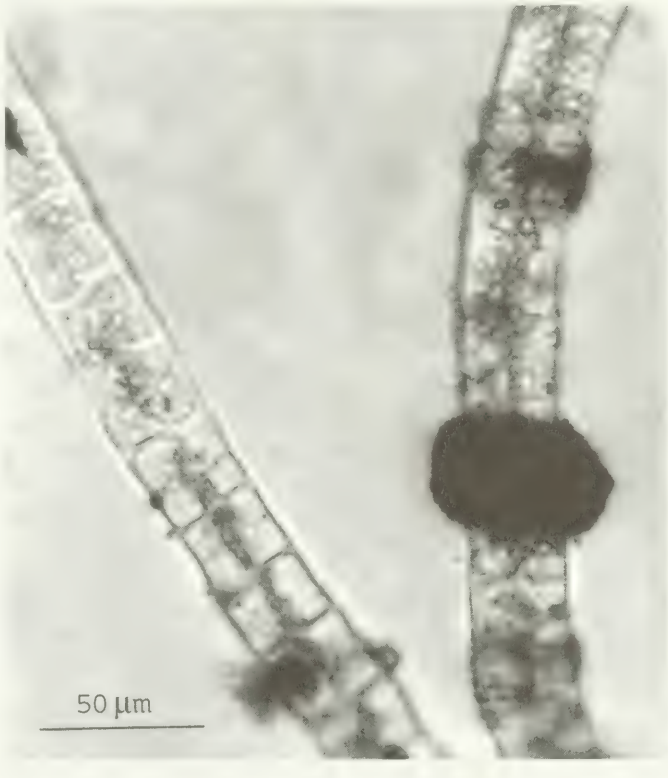

FIGURE 3. Photomicrograph (1000×) of filaments of *Percursaria percursa* from a hypersaline spring west of Lake Winnipegosis. The biseriate cells are paired in two longitudinal rows in each filament. Note the large accumulation of material on the right strand that imparts a rust-red color to the mats as a whole, although the filaments themselves are green. The scale bar represents 50 µm.

N and P concentrations [1-200 µM PO_4^{3-}, 10-1000 µM NO_3^-, 1-100 µM NH_4^+] (Taylor et al. 2001). Growth of "green tide" algae like *P. percursa* is generally enhanced by eutrophic conditions, but the springs west of Lake Winnipegosis are pristine discharges, with the only potential sources of significant amounts of N and P from sporadic incidences of bird defecation.

The distribution of *P. percursa* was compared to water chemistry parameters by principle component analysis (PCA) using The Unscrambler® 7.6, a multivariate statistical software package. The first two axes of the PCA explained 86% of the total variance and revealed differences in the water chemistry between hypersaline springs with and without mat communities (Figure 4). PCA axis 1 explained 65% of the total variation between the springs and clearly separated hypersaline springs with mat communities from those without. Total dissolved solids (TDS = the sum of major cations and anions) and chloride explained 95.2 and 94.6% of the variance in the scores of the hypersaline springs on axis 1, respectively. All hypersaline springs with mat communities were situated to the right of axis 1 and positively correlated to TDS and chloride, indicating that high salinities are required for the growth of *P. percursa*. Iron and sulphate concentrations also appeared to be correlated to the presence of mats and explained 49.0 and 56.5% of the variance on axis 1, respectively. Additionally, PCA axis 2 explained 21% of the variation between the hypersaline springs. On this axis pH was the most important factor, explaining 55.3% of the variance on axis 2, and indicated that the growth of *P. percursa* occurred in springs with lower pH.

In addition to the above parameters, other factors must also determine the distribution, as not all springs at each site contain mats of *P. percursa*. The temperature of the waters varied seasonally, ranging from 5°C (temperature of the source water) up to 30°C in the summer, but densities did not correlate with temperature. Growth of the organism is restricted to springs with high flow rates that form open pools, and it is not observed in low-flowing seeps in the area even if the water chemistry is compatible. In addition, distinct pools or cauldrons just a few meters apart, or even touching, had extensive growth of mats in one pool and nothing in the other. Considering the motility of the species, and its widespread distribution in the area, lack of colonization would not explain the patchy distribution. There could be a subtle difference in the chemistry of the water at each outlet, although chemical measurements to date indicate that all the water from these sites originates from the same source. There could be a difference in predation to explain the disparity of mat development in different springs. Studies

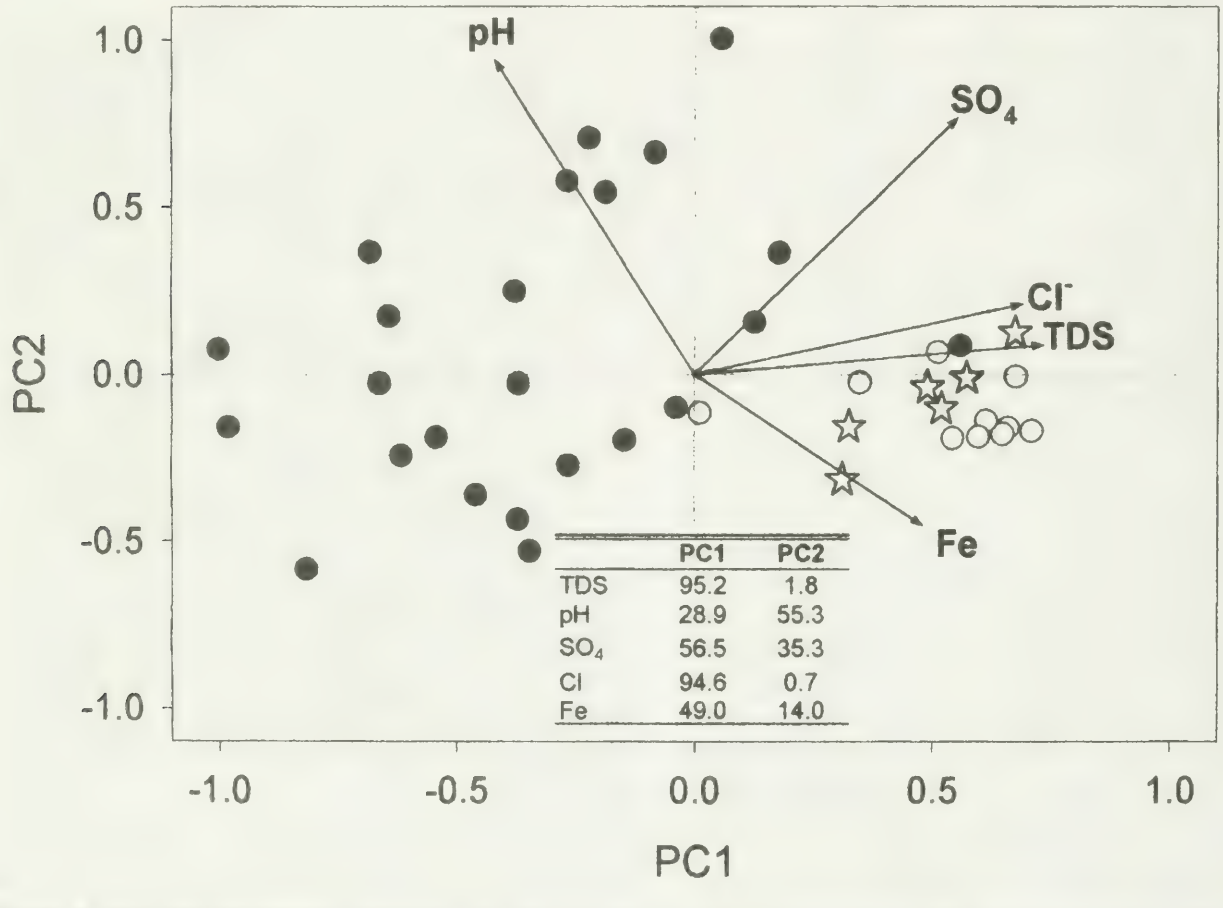

FIGURE 4. Principle component analysis (PCA) ordination biplot displaying grouping of hypersaline springs with respect to water chemistry. The symbols represent springs without *P. percursa* (closed circles), with mat communities not yet confirmed as *P. percursa* (open circles), and with confirmed mats of *P. percursa* (open stars). The inset table lists the relative contributions (in %) of each chemical parameters to the variance on each of the two axes.

of rotifer populations in areas containing *P. percursa* found that this predator is limited by high salt concentrations as well as higher temperatures (Saunders-Davies 1998). The dynamics of growth and predation require further study at this site.

Further research

The ability of *P. percursa* to grow and thrive in this extreme environment certainly merits further scientific investigation. The extent to which this dominant primary producer supports an entire ecosystem of microbes in the mat community is the subject of ongoing research. This organism supports a dynamic community of anaerobes including sulphate-reducing bacteria and methanogens. The potential for methanogenic fermentation of *P. percursa* biomass at lower salinities has been demonstrated previously, and proposed as a future mechanism for the production of a renewable source of biogas (Schramm and Lehnberg 1984). The extent to which this organism affects the precipitation and mineralization of carbonates (calcium carbonate) and iron (hematitic- to limonitic) at these sites (Bezys et al. 1997), causing the distinctive reddish brown sinter or tufa mounds of springs on the salt pans, also requires further investigation. These mats also likely support a unique community of invertebrates and epiphytic algae, which to date have not been investigated to our knowledge.

Acknowledgments

This research was supported by NSERC. Thanks to K. Dawson, H. Grover, and S. Mohammed for collection of samples. Thanks to H. Kling at the Freshwater Institute (Winnipeg, Manitoba) for helpful advice regarding the identification of *P. percursa*.

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Received 5 July 2004
Accepted 25 February 2005

New Distribution Records and Biogeography of *Calligrapha* Species (Leaf Beetles), in North America (Coleoptera: Chrysomelidae, Chrysomelinae)

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Gómez-Zurita, Jesús. 2005. New distribution records and biogeography of *Calligrapha* species, (Leaf Beetles), in North America (Coleoptera: Chrysomelidae, Chrysomelinae). Canadian Field-Naturalist 119(1): 88-100.

The study of a large number of collection specimens from the US National Museum of Natural History belonging to the genus *Calligrapha* Chevrolat (Chrysomelidae) from the Nearctic region has provided with one new province record and one new species record for Canada and 63 new US State records for a total of 20 taxa. These new records usually correspond to adjacent areas to already identified ranges of distribution, expanding considerably the known geographical boundaries of the species studied. The zoogeography of the genus *Calligrapha* in North America is discussed based on the updated information on the distribution of the genus.

Key Words: *Calligrapha*, Leaf beetles, Nearctic region, zoogeography, biodiversity, distribution, new records.

The New World chrysomeline genus *Calligrapha* Chevrolat 1837 (Chrysomelidae) is currently recognized to have more than 80 species and subspecies distributed from Alaska and all Canada provinces (and Northwest Territories) to Argentina in South America (Blackwelder 1982; Arnett et al. 2002). Approximately one third of these species are present in North America north of Mexico (Arnett 1968; Arnett et al. 2002), the biogeographical region for which we have a better knowledge of the taxonomy and also geographical ranges of the species. This group is best known taxonomically and biologically from Eastern Canada, thanks to the observations of W. J. Brown (1940, 1945, 1958) and J. G. Robertson (1966), who studied in detail their distribution along with trophic preferences and their cytology. But even for a region like North America and a well-studied zoological group like the Chrysomelidae, information about distribution is usually scattered in catalogues of regional fauna (e.g., Blatchley 1910; Balsbaugh and Hays 1972; Clark 2000) or in the form of far from complete State records in more general species accounts (e.g., Wilcox 1975; Downie and Arnett 1996; Riley et al. 2003). Besides, our understanding about species distributions can be in particular cases quite confuse due to unreliable taxonomic designations for morphologically very similar species. Problematic species identification in *Calligrapha* is rather common for several closely related taxa because it requires information about host plants, most of the times lacking from collection specimens, or large series of individuals to capture the species variation within the species.

In order to characterize in higher detail the geographical ranges of the species of *Calligrapha* in North America it is still required extensive field work in new and already prospected areas, paying particular attention to the plants to which the beetles appear associated in the field. Furthermore, the study of the collections in Museums has logically enormous potential in providing this type of information, with new and interesting data to be gathered. Both sources of information are used in this work, together with published data, to present an updated account of the information about distribution for 20 taxa of *Calligrapha* in North America for which several new state records have been found. In most of the cases, these new records correspond to regions adjacent to the already identified areas of distribution of each taxon, broadening the known distributional ranges of these species. The study of a single, but large, source of Museum material like that deposited in the Smithsonian Institution has proved very fruitful in providing with new data. Nevertheless, it is possible that the investigation of the accessions and undetermined specimens from other Museums, particularly in Canadian and US Institutions, will certainly add new useful information about the distribution of these beetles.

Materials and Methods

Specimens studied

Collection data for some specimens were obtained by the author in two entomological campaigns in northeastern North America in the summer of 2001 and eastern Canada in 2002. Field work done independently by Daniel J. Funk in the same areas also provided with important new distribution records. A large number of accessions from the collection at the US National Museum of Natural History (NMNH; Smithsonian Institution, Washington, DC) were also studied, which included 2030 specimens belonging to the genus *Calligrapha*.

Species identification

All the specimens reported here and all the other museum accessions available were personally identified by the author of this work, who has collected and investigated the taxonomy and phylogeny of the genus *Calligrapha* since 2000. The museum accessions were sorted out separating all the species that can be easily identified at a glance because of their characteristic features, such as the species belonging to the subgenera *Bidensomela, Coreopsomela* and *Graphicallo*, or the *Calligrapha s. str.* species *C. apicalis, C. ignota, C. rowena,* and others. The other samples and every single specimen reported in this work were key out using the comprehensive keys for North American *Calligrapha* in Brown (1945) and Wilcox (1972), but were also compared with correctly identified material in the British Natural History Museum Entomology collection and in the reference specimen and picture collection of the author. Moreover, the individual specimens were always compared with the original description of the species to further confirm the identity. The over 2000 identified specimens were labeled with their taxonomic assignment on white cardboard labels including "J. Gómez-Zurita det." and the year when the identification was done. The comparatively few specimens collected by D. J. Funk and other colleagues for the author's research on the molecular phylogeny of the genus are temporally held in the author's collection before the studies are finished and their final depository decided. The remaining specimens belong and are deposited in the US NMNH collection.

Data presentation

For each *Calligrapha* species, distribution information is given by state for published records. Full details, including county and specific locality data when known, collection date, the name of the collector, as well as the number of specimens studied, are given in those cases where a new state record has been registered. Similar distributional information is presented graphically on a series of maps where references from the literature and new records are distinguished (Figure 1 a-p).

Results

Calligrapha alni Schaeffer 1928 (Figure 1a)

Canada: Alberta (Brown 1945; Robertson 1966; Bousquet 1991; Riley et al. 2003), Manitoba (Brown 1945; Robertson 1966; Bousquet 1991; Riley et al. 2003), New Brunswick (Bousquet 1991; Riley et al. 2003), Nova Scotia (Schaeffer 1928; Brown 1945; Robertson 1966; Wilcox 1972, 1975; Bousquet 1991; Cavey 1994; Downie and Arnett 1996; Riley et al. 2003), Ontario (Schaeffer 1928; Robertson 1966; Bousquet 1991; Cavey 1994; Riley et al. 2003), Quebec (Robertson 1966; Bousquet 1991; Downie and Arnett 1996; Riley et al. 2003), Saskatchewan (Robertson 1966; Bousquet 1991; Riley et al. 2003). U.S.A.: Maine (Schaeffer 1928; Cavey 1994; Downie and Arnett 1996; Riley et al. 2003), Maryland (Cavey 1994; Downie and Arnett 1996; Riley et al. 2003), Massachusetts (Schaeffer 1928; Cavey 1994; Riley et al. 2003), Michigan (Wilcox 1972, 1975; Cavey 1994; Downie and Arnett 1996; Riley et al. 2003), Minnesota (Riley et al. 2003), New Jersey (Schaeffer 1933; Cavey 1994; Riley et al. 2003), New York (Schaeffer 1933; Cavey 1994; Downie and Arnett 1996; Riley et al. 2003), Ohio (Wilcox 1954; Cavey 1994; Riley et al. 2003), Vermont (Schaeffer 1928; Cavey 1994; Riley et al. 2003), West Virginia (Wilcox 1972, 1975; Cavey 1994; Downie and Arnett 1996; Clark 2000; Riley et al. 2003), Wisconsin (Cavey 1994; Riley et al. 2003).

NEW HAMPSHIRE: Coos Co., Jefferson, 4 May 1936, A. E. Brower collector (1)

Calligrapha alnicola Brown 1945 (Figure 1b)

Canada: New Brunswick (Brown 1945; Robertson 1966; Bousquet 1991; Clark 2000; Riley et al. 2003), Nova Scotia (Bousquet 1991; Riley et al. 2003), Ontario (Brown 1945; Robertson 1966; Wilcox 1972, 1975; Bousquet 1991; Downie and Arnett 1996; Riley et al. 2003), Quebec (Brown 1945; Robertson 1966; Wilcox 1972, 1975; Bousquet 1991; Downie and Arnett 1996; Riley et al. 2003). U.S.A.: Kentucky (Clark 2000; Riley et al. 2003), Maine (Clark 2000; Riley et al. 2003), Michigan (Clark 2000; Riley et al. 2003), New York (Riley et al. 2003).

MINNESOTA: Cook Co., route 61, North, 47°56.879'N 89°41.875'W, 14 August 2004, on *Alnus* sp., D. J. Funk collector (2)

NEW HAMPSHIRE: Grafton Co., Hanover, K. W. Cooper coll. (1); Strafford Co., Durham, 12 June 1907 (1)

VERMONT: Bennington Co., East Dorset, 8 June 1959, C. T. Parsons coll. (1); Orleans Co., near Barton, 16 July 2001, on *Alnus* sp., D. J. Funk collector (1)

WEST VIRGINIA: Tucker Co., Canaan Valley Resort S. P., 18 July 2001, J. Gómez-Zurita and D. P. Duran collector (1)

WISCONSIN: Bayfield Co., Bayfield, Wickham collector (1)

Calligrapha amator Brown 1945 (Figure 1c)

Canada: Ontario (Brown 1945; Robertson 1966; Wilcox 1972, 1975; Bousquet 1991; Downie and Arnett 1996; Riley et al. 2003). U.S.A.: Wyoming (Lawson 1976; dubious according to Riley et al. 2003).

QUEBEC: Quebec, Maisonneuve, 25 August 1901, C. Stevenson collector (3); St. Lawrence River, St. Regis, on *Tilia americana*, C. O. Houghton collector (1)

Calligrapha amelia Knab 1909 (Figure 1c)

U.S.A.: Alabama (Balsbaugh and Hays 1972; Riley et al. 2003), District of Columbia (Knab 1909; Leng 1920; Riley et al. 2003), Maryland (Knab 1909; Riley et al. 2003), New Jersey (Knab 1909; Wilcox 1972, 1975; Riley et al. 2003), New York (Knab 1909; Leng 1920; Leonard 1926; Wilcox 1972; Downie and Arnett 1996; Riley et al. 2003), Ohio (Wilcox 1954, 1972, 1975; Downie and Arnett 1996; Riley et al. 2003), Rhode Island (Sikes 1999*; Riley et al. 2003), South Carolina (Kirk 1970; Riley et al. 2003), Virginia (Knab 1909; Leng 1920; Wilcox 1972, 1975; Downie and Arnett 1996; Riley et al. 2003), West Virginia (Knab 1909; Clark 2000; Riley et al. 2003).

CONNECTICUT: New London Co., Lyme, 28 May 1918, W. S. Fisher collector, on *Alnus* sp. (1)

FIGURE 1. Geographical distributions of several *Calligrapha* species in North America. The shaded areas represent published province (Canada) or US State records and the symbols correspond to the new province or state records reported in this work for *C. alni* (a), *C. alnicola* (b), *C. amator* and *C. amelia* (c), *C. apicalis* (d), *C. bidenticola* (e), *C. californica s. l.* (f), *C. confluens* (g), *C. ignota* (h).

DELAWARE: Sussex Co., Rehoboth, 6 April 1943, G. H. Dieke collector, in beach washup (1)

GEORGIA: De Kalb Co., 5 May 1951, H. R. Dodge collector (1); Spaulding Co., Experiment, 29 March 1937, on peach (1)

MASSACHUSETTS: F. Knab collector (1)

PENNSYLVANIA: Cumberland Co., Mount Holly Springs, 1 September 1918, R. M. Fonts collector (1); Dauphin Co., Heckton Mills, 8 July 1910, P. R. Myers collector (1)

Calligrapha apicalis Notman 1919 (Figure 1d)

Canada: Ontario (Brown 1945; Robertson 1966; Bousquet 1991; Riley et al. 2003), Quebec (Brown 1945; Robertson 1966; Wilcox 1972, 1975; Bousquet 1991; Downie and Arnett 1996; Riley et al. 2003). U.S.A.: Michigan (Wilcox 1972, 1975; Downie and Arnett 1996; Riley et al. 2003), New York (Notman 1919; Leonard 1926; Wilcox 1972, 1975; Downie and Arnett 1996; Riley et al. 2003).

MARYLAND: Calvert Co., Plum Point, 28 May 1922, L. L. Buchanan collector (1)

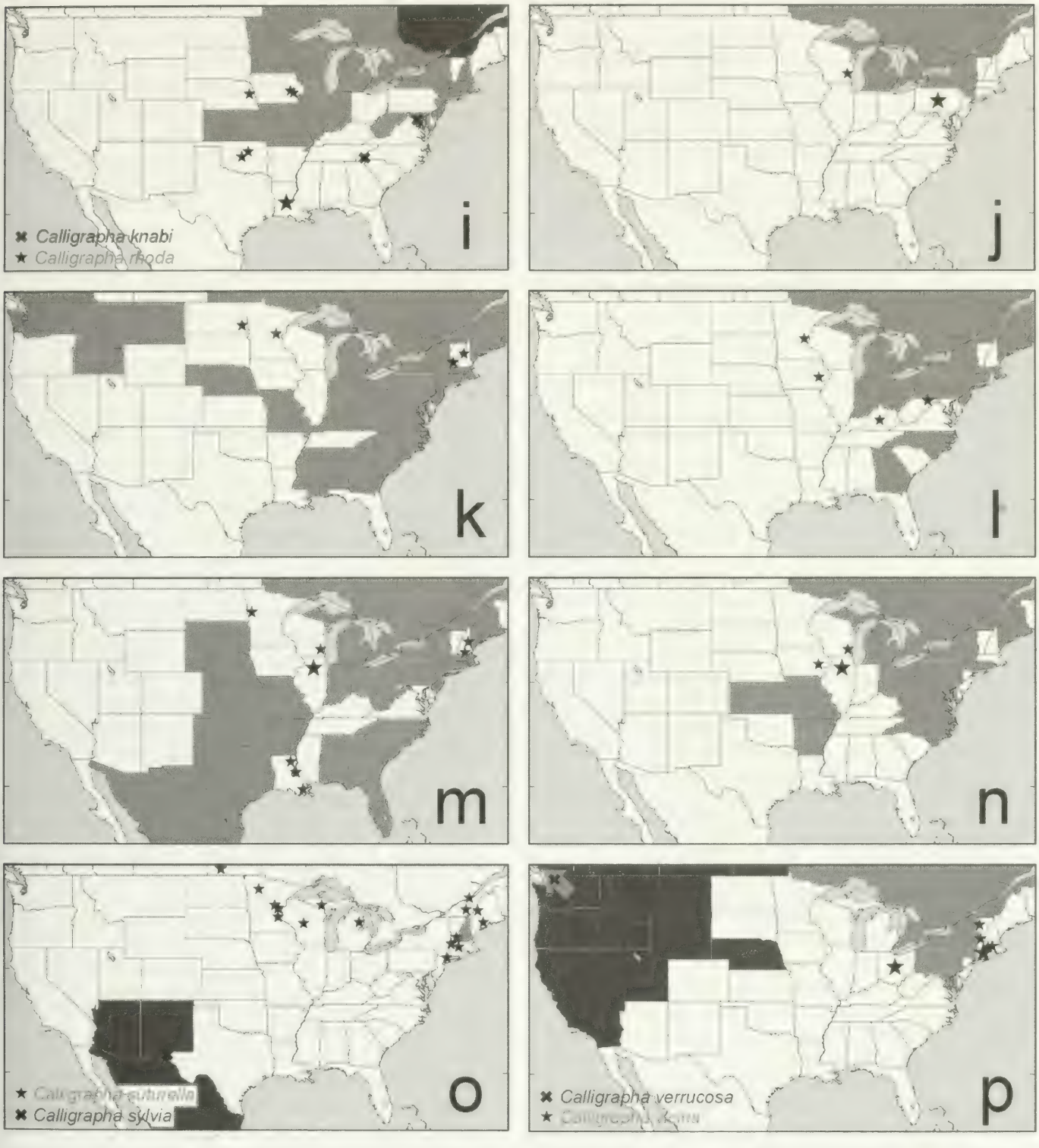

FIGURE 1. (Continued). *C. knabi* and *C. rhoda* (i), *C. ostryae* (j), *C. philadelphica* (k), *C. rowena* (l), *C. scalaris* (m), *C. spiraea* (n), *C. suturella* and *C. sylvia* (o), and *C. verrucosa* and *C. vicina* (p). The symbols are approximately placed on the localities in the collection data. Larger symbols are used to identify US State records without specific locality.

Calligrapha bidenticola Brown 1945 (Figure 1e)

Canada: New Brunswick (Brown 1945; Robertson 1966; Wilcox 1972, 1975; Downie and Arnett 1996; Riley et al. 2003), Ontario (Brown 1945; Robertson 1966; Bousquet 1991; Riley et al. 2003), Quebec (Brown 1945; Robertson 1966; Bousquet 1991; Riley et al. 2003). U.S.A.: Alabama (Balsbaugh and Hays 1972; Wilcox 1972; Riley et al. 2003), Arkansas (Riley et al. 2003), Colorado (Leng 1920; Wilcox 1972, 1975; Downie and Arnett 1996; Riley et al. 2003), Connecticut (Britton 1920; Brown 1945; Riley et al. 2003), District of Columbia (Riley et al. 2003), Florida (Monrós 1955; Wilcox 1972, 1975; Riley et al. 2003), Georgia (Riley et al. 2003), Illinois (Riley et al. 2003), Indiana (Blatchley 1910; Leng 1920; Downie and Arnett 1996; Riley et al. 2003), Iowa (Riley et al. 2003), Kansas (Douglass 1929; Riley et al. 2003), Kentucky (Riley et al. 2003), Louisiana (Riley et al. 2003), Maine (Riley et al. 2003), Maryland (Riley et al. 2003), Massachusetts (Downie and Arnett 1996; Riley et al. 2003), Missouri (Riley and Enns 1979; Riley et al. 2003), Nebraska (Powell 1932; Riley et al. 2003), New Jersey (Riley et al. 2003), New York (Leonard 1926; Downie and Arnett 1996; Riley et al. 2003),

Ohio (Hughes 1944; Wilcox 1954; Riley et al. 2003), Oklahoma (Shaddy and Drew 1967), Pennsylvania (Riley et al. 2003), Rhode Island (Davis 1904; Sikes 1999*; Riley et al. 2003), South Dakota (Johnson 1930; Kirk and Balsbaugh 1975; Riley et al. 2003), Tennessee (Riley et al. 2003), Texas (Wilcox 1972, 1975; Downie and Arnett 1996; Riley et al. 2003), West Virginia (Clark 2000; Riley et al. 2003), Wisconsin (Riley et al. 2003).

DELAWARE: Dewey Beach to Maryland, Assateague Park, 1 July 1985, dead on beach, P. Schaefer collector (1)

MICHIGAN: E. S. George Res., Pinckney, 8 June 1947, B. Summerville collector (2)

Calligrapha californica s. l. (Linell 1896) (Figure 1f)

Canada: Alberta (Beller and Hatch 1932; Brown 1945; Bousquet 1991; Riley et al. 2003), British Columbia (Brown 1945; Hatch 1971; Wilcox 1972, 1975; Bousquet 1991; Riley et al. 2003), Manitoba (Brown 1945; Bousquet 1991; Riley et al. 2003), New Brunswick (Brown 1945; Bousquet 1991; Riley et al. 2003), Northwest Territories (Bousquet 1991; Riley et al. 2003), Nova Scotia (Beller and Hatch 1932; Brown 1945; Riley et al. 2003), Ontario (Morris 1914; Bousquet 1991; Riley et al. 2003), Prince Edward Island (Riley et al. 2003), Quebec (Brown 1945; Robertson 1966; Bousquet 1991; Riley et al. 2003), Saskatchewan (Brown 1945; Bousquet 1991; Riley et al. 2003). U.S.A.: California (Leng 1920; Beller and Hatch 1932; Schaeffer 1933; Brown 1945; Monrós 1955; Wilcox 1972, 1975; Riley et al. 2003), Colorado (Beller and Hatch 1932; Riley et al. 2003), Connecticut (Britton 1920; Brown 1945; Riley et al. 2003), District of Columbia (Beller and Hatch 1932; Riley et al. 2003), Idaho (Schaeffer 1933; Hatch 1971), Indiana (Blatchley 1910; Leng 1920; Beller and Hatch 1932; Riley et al. 2003), Iowa (Riley et al. 2003), Kansas (Douglass 1929; Riley et al. 2003), Maine (Wilcox 1972, 1975; Downie and Arnett 1996; Riley et al. 2003), Maryland (Riley et al. 2003), Massachusetts (Riley et al. 2003), Michigan (Lawson 1976; Riley et al. 2003), Minnesota (Riley et al. 2003), Montana (Hatch 1971; Riley et al. 2003), Nebraska (Powell 1932; Riley et al. 2003), New Jersey (Riley et al. 2003), New York (Leonard 1926; Lawson 1976; Riley et al. 2003), North Dakota (Wilcox 1972, 1975; Downie and Arnett 1996), Ohio (Hughes, 1944; Wilcox 1954; Riley et al. 2003), Oregon (Hatch 1971), Pennsylvania (Riley et al. 2003), Rhode Island (Davis 1904; Sikes 1999*; Riley et al. 2003), South Carolina (Riley et al. 2003), South Dakota (Johnson 1930; Wilcox 1972, 1975; Kirk and Balsbaugh 1975; Riley et al. 2003), Utah (Riley et al. 2003), Virginia (Williams 1989; Riley et al. 2003), Washington (Beller and Hatch 1932; Hatch 1971; Riley et al. 2003), West Virginia (Clark 2000; Riley et al. 2003), Wisconsin (Riley et al. 2003), Wyoming (Lawson 1976; Riley et al. 2003).

ILLINOIS (*C. c. coreopsivora*): Cook Co., Chicago, 30 May 1902, on the beach, A. B. Wolcott collector (1); Cook Co., Chicago, 1 June 1904, A. B. Wolcott coll. (1)

VERMONT (*C. c. coreopsivora*): Bennington Co., East Dorset, 8 July 1959, C. Parsons collector (12); Chittenden Co., Colchester, Colchester Pond, 9 May 1975, M. Langworthy collector (1); LaPlatt River, 20 September 1979, B. J. Norman collector (1)

Calligrapha confluens Schaeffer 1928 (Figure 1g)

Canada: New Brunswick (Bousquet 1991; Riley et al. 2003), Nova Scotia (Schaeffer 1928; Brown 1945; Robertson 1966; Wilcox 1972, 1975; Bousquet 1991; Downie and Arnett 1996; Riley et al. 2003), Ontario (Brown 1945; Robertson 1966; Bousquet 1991; Riley et al. 2003), Quebec (Brown 1945; Robertson 1966; Bousquet 1991; Riley et al. 2003). U.S.A.: Maine (Schaeffer 1928; Riley et al. 2003), Massachusetts (Schaeffer 1928; Wilcox 1972, 1975; Downie and Arnett 1996; Riley et al. 2003), Nebraska (Powell 1932; reported as dubious by Riley et al. 2003), New York (Brown 1945; Riley et al. 2003), Virginia (Brown 1945), West Virginia (Clark 2000; Riley et al. 2003).

MINNESOTA: Cass Co., Gull Lake, 3 June 1925, F. Uhler collector (1)

NEW HAMPSHIRE: Mt. Plsnt. Hse., July, A. Feynes collection (1)

PENNSYLVANIA: Erie Co., North East, 4 July 1916, on *Alnus*, R. A. Cushman collector (1)

VERMONT: Chittenden Co., Westford, 1 October 1968, D. L. Pouliot collector (1); Caledonia Co., nr Sheffield, 20 August 1999, on *Alnus* sp., Daniel J. Funk collector (1)

Calligrapha ignota Brown 1945 (Figure 1h)

Canada: Manitoba (Bousquet 1991; Riley et al. 2003), New Brunswick (Brown 1945; Bousquet 1991; Riley et al. 2003), Nova Scotia (Brown 1945; Wilcox 1972, 1975; Bousquet 1991; Downie and Arnett 1996; Riley et al. 2003), Ontario (Brown 1945; Bousquet 1991; Riley et al. 2003), Prince Edward Island (Brown 1945; Riley et al. 2003), Quebec (Riley et al. 2003). U.S.A.: Maine (Riley et al. 2003), Minnesota (Wilcox 1972, 1975; Downie and Arnett 1996; Riley et al. 2003), North Carolina (Riley et al. 2003), Ohio (Riley et al. 2003), Pennsylvania (Linnell 1896; Brown 1945; Wilcox 1972; Downie and Arnett 1996; Riley et al. 2003), Tennessee (Wilcox 1972, 1975; Downie and Arnett 1996; Riley et al. 2003), West Virginia (Clark 2000; Riley et al. 2003).

MICHIGAN: Allegan Co., Macatawa B'h, 10 June 1906, A. B. Wolcott collector (2); Marquette Co., Marquette, June 1928, Van Dyke Collection (2)

NEW YORK: Erie Co., Buffalo, E. P. V. collector, Collection Ashmead (1); Long Island, 18 April 1903, Sherman Collection (1); Long Island, Sherman Collection (4); New York, Sherman Collection (2)

Calligrapha knabi Brown, 1940 (Figure 1i)

Canada: Manitoba (Bousquet 1991; Riley et al. 2003), Ontario (Bousquet 1991; Riley et al. 2003), Quebec (Brown 1940, 1945; Wilcox 1972, 1975; Bousquet 1991; Downie and Arnett 1996; Riley et al. 2003).

MARYLAND: Prince George's Co., Accokeek, 24 April 2003, on *Cornus amomum*, C. L. & S. L. Staines collector (2)

NORTH CAROLINA: Jackson Co., Balsam, 25 June 1973, Rosenberg Collection (1)

Calligrapha ostryae Brown 1945 (Figure 1j)

Canada: Ontario (Brown 1945; Robertson 1966; Wilcox 1972, 1975; Bousquet 1991; Downie and Arnett 1996; Riley et al. 2003), Quebec (Brown 1945; Robertson 1966; Riley et al.

2003). U.S.A.: Michigan (Brown 1945; Robertson 1966; Wilcox 1972, 1975; Downie and Arnett 1996; Riley et al. 2003), New York (Brown 1945; Robertson 1966; Wilcox 1972, 1975; Downie and Arnett 1996; Riley et al. 2003).

PENNSYLVANIA: Pennsylvania, F. Knab Collection (1)

WISCONSIN: Milwaukee Co., Milwaukee, Milwaukee Public Museum, F. Knab Collection (1); Milwaukee Co., 20 July 1900, F. R. collector, F. Knab Collection (2)

Calligrapha philadelphica (Linnaeus 1758) (Figure 1k)

Canada: British Columbia (Brown 1945; Robertson 1966; Hatch 1971; Wilcox 1972, 1975; Lawson 1976; Bousquet 1991; Downie and Arnett 1996; Riley et al. 2003), Manitoba (Brown 1945; Robertson 1966; Bousquet 1991; Downie and Arnett 1996; Riley et al. 2003), New Brunswick (Brown 1945; Robertson 1966; Wilcox 1972, 1975; Bousquet 1991; Downie and Arnett 1996; Riley et al. 2003), Nova Scotia (Bousquet 1991; Riley et al. 2003), Ontario (Morris 1914; Brown 1945; Robertson 1966; Bousquet 1991; Riley et al. 2003), Quebec (Brown 1945; Robertson 1966; Bousquet 1991; Downie and Arnett 1996; Riley et al. 2003), Saskatchewan (Bousquet 1991; Riley et al. 2003). U.S.A.: Alabama (Balsbaugh and Hays 1972; Riley et al. 2003), Connecticut (Britton 1920; Riley et al. 2003), District of Columbia (Riley et al. 2003), Georgia (Wilcox 1972, 1975; Downie and Arnett 1996; Riley et al. 2003), Idaho (Hatch 1971; Downie and Arnett 1996), Indiana (Blatchley 1910; Leng 1920), Kentucky (Riley et al. 2003), Maine (Downie and Arnett 1996; Riley et al. 2003), Maryland (Schroder et al. 1996; Riley et al. 2003), Massachusetts (Riley et al. 2003), Michigan (Riley et al. 2003), Mississippi (Dozier 1921; Riley et al. 2003), Missouri (Rogers 1856; Riley et al. 2003), Montana (Hatch 1971; Riley et al. 2003), Nebraska (Linell 1896; Leng 1920; Powell 1932; Wilcox 1972, 1975; Downie and Arnett 1996; Riley et al. 2003), New Jersey (Riley et al. 2003), New York (Leonard 1926; Downie and Arnett 1996; Riley et al. 2003), North Carolina (Brimley 1938; Riley et al. 2003), Ohio (Hughes, 1944; Wilcox 1954; Downie and Arnett 1996; Riley et al. 2003), Pennsylvania (Brown 1945; Riley et al. 2003), Rhode Island (Davis 1904; Sikes 1999*; Riley et al. 2003), South Carolina (Kirk 1970; Riley et al. 2003), Virginia (Riley et al. 2003), Washington (Hatch 1971; Downie and Arnett 1996), West Virginia (Clark 2000; Riley et al. 2003).

MINNESOTA: Kanabec Co., Mora, 20 June 1907, 27 June 1907, 25 July 1907, 1 August 1907, R. A. Vickery collector (1, 2, 2, 1)

NEW HAMPSHIRE: Grafton Co., Woodsville, 31 July 2001, on *Cornus stolonifera*, J. Gómez-Zurita collector (1); Grafton Co., Hanover, K. W. Cooper (6)

NORTH DAKOTA: Cass Co., Fargo, 20 July 1918, I. N. Gabrielson collector (1)

VERMONT: Bennington Co., East Dorset, 28 June 1957, C. T. Parsons collector (1)

Calligrapha rhoda Knab 1909 (Figure 1i)

Canada: Manitoba (Bousquet 1991; Riley et al. 2003), Ontario (Brown 1945; Bousquet 1991; Riley et al. 2003). U.S.A.: Connecticut (Britton 1920; Riley et al. 2003), Illinois (Knab 1909; Riley et al. 2003), Indiana (Knab 1909; Blatchley 1910; Leng 1920; Wilcox 1972; Riley et al. 2003), Kansas (Knab 1909; Leng 1920; Wilcox 1972, 1975; Downie and Arnett 1996; Riley et al. 2003), Maryland (Knab 1909; Wilcox 1972, 1975; Downie and Arnett 1996; Riley et al. 2003), Massachusetts (Knab 1909; Downie and Arnett 1996; Riley et al. 2003), Michigan (Knab 1909; Riley et al. 2003), Minnesota (Knab 1909; Riley et al. 2003), Missouri (Knab 1909; Wilcox 1972; Riley et al. 2003), New Hampshire (Knab 1909; Leng 1920; Wilcox 1972, 1975; Downie and Arnett 1996; Riley et al. 2003), New Jersey (Riley et al. 2003), New York (Leonard 1926; Riley et al. 2003), Rhode Island (Sikes 1999*; Riley et al. 2003), West Virginia (Clark 2000; Riley et al. 2003), Wisconsin (Knab 1909; Leng 1920; Wilcox 1972, 1975; Downie and Arnett 1996; Riley et al. 2003).

IOWA: Johnson Co., Iowa City, May 1923, Wickham collector (1); Muscatine Co., Muscatine, 11 June 1917, C. E. Smith collector (1); Iowa, Van Dyke Collection (1)

LOUISIANA: Louisiana, F. Knab Collection (1)

NEBRASKA: Cuming Co., West Point, June 1888, Koebele Collection (1)

OKLAHOMA: Oklahoma Co., Harrah, 23 May 1916, W. D. Pierce collector (1); Payne Co., 1961, John F. Reinert collector (3)

Calligrapha rowena Knab 1909 (Figure 1l)

Canada: Manitoba (Bousquet 1991; Riley et al. 2003), New Brunswick (Brown 1945; Robertson 1966; Bousquet 1991; Riley et al. 2003), Nova Scotia (Brown 1945; Robertson 1966; Riley et al. 2003), Ontario (Knab 1909; Brown 1945; Robertson 1966; Bousquet 1991; Riley et al. 2003), Quebec (Knab 1909; Brown 1945; Robertson 1966; Wilcox 1972, 1975; Bousquet 1991; Downie and Arnett 1996; Riley et al. 2003). U.S.A.: Connecticut (Knab 1909; Britton 1920; Riley et al. 2003), Georgia (Wilcox 1972, 1975; Downie and Arnett 1996; Riley et al. 2003), Indiana (Blatchley 1910; Leng 1920), Maine (Riley et al. 2003), Massachusetts (Knab 1909; Riley et al. 2003), Michigan (Wilcox 1972, 1975; Downie and Arnett 1996; Riley et al. 2003), New Jersey (Riley et al. 2003), New York (Leonard 1926; Brown 1945; Robertson 1966; Downie and Arnett 1996; Riley et al. 2003), North Carolina (Brimley 1938; Riley et al. 2003), Ohio (Wilcox 1954; Riley et al. 2003), Pennsylvania (Knab 1909; Clark 2000; Riley et al. 2003).

IOWA: Johnson Co., Iowa City, 4 July 1918, on *Cornus* sp., L. W. Lindsey collector (1)

KENTUCKY: Rockcastle Co., Pine Hill Cave, 27 March 1967, Reddell and Andrews collector (1)

MARYLAND: Garret Co., Oakland, 31 May 1942, 2 June 1942, on *Cornus* sp., G. H. Dieke collector (1, 1); Garret Co., Oakland, 6 June 1942, G. H. Dieke collector (1)

MINNESOTA: Cedar Creek Natural History Area, 45°40.000'N 93°15.000'W, 16 September 2004, on *Cornus* sp., D. J. Funk collector (1)

Calligrapha scalaris (Le Conte 1824) (Figure 1m)

Canada: Manitoba (Bousquet 1991; Riley et al. 2003), Ontario (Morris 1914; Brown 1945; Robertson 1966; Bousquet 1991; Riley et al. 2003), Quebec (Brown 1945; Robertson

1966; Wilcox 1972, 1975; Bousquet 1991; Downie and Arnett 1996; Riley et al. 2003). U.S.A.: Alabama (Balsbaugh and Hays 1972; Riley et al. 2003), Arkansas (Riley et al. 2003), Connecticut (Britton 1920; Riley et al. 2003), District of Columbia (Riley et al. 2003), Florida (Le Conte 1824; Leng 1920; Blatchley 1924; reported as dubious by Riley et al. 2003), Georgia (Wilcox 1972, 1975; Downie and Arnett 1996; Riley et al. 2003), Indiana (Blatchley 1910; Leng 1920; Powell 1932; Downie and Arnett 1996), Kansas (Douglass 1929; Robertson 1966; Riley et al. 2003), Maine (Riley et al. 2003), Massachusetts (Riley et al. 2003), Michigan (Downie and Arnett 1996), Missouri (Jacoby 1880-1888; Riley and Enns 1979), Nebraska (Rogers 1856; Linell 1896; Leng 1920; Powell 1932; Riley et al. 2003), New Jersey (Riley et al. 2003), New York (Le Conte 1824; Leonard 1926; Downie and Arnett 1996; Riley et al. 2003), North Carolina (Brimley 1938; Riley et al. 2003), Ohio (Hughes 1944; Wilcox 1954; Riley et al. 2003), Oklahoma (Fenton 1944; Shaddy and Drew 1967; Riley et al. 2003), Pennsylvania (Riley et al. 2003), Rhode Island (Davis 1904; Sikes 1999; Riley et al. 2003), South Carolina (Kirk 1969, 1970; Riley et al. 2003), South Dakota (Johnson 1930; Kirk and Balsbaugh 1975; Riley et al. 2003), Texas (Linell 1896; Leng 1920; Wilcox 1972, 1975; Downie and Arnett 1996; Riley et al. 2003), West Virginia (Clark 2000; Riley et al. 2003). Mexico (Jacoby 1880-1888; Blackwelder 1982).

ILLINOIS: N. Illinois, F. Knab Collection (1)

LOUISIANA: Franklin Co., Wisner, February 22-23, under bark of elm, R. A. St. George collector (2); Orleans Co., New Orleans, 20 January 1944, E. S. Ross collector (4)

MINNESOTA: Clay Co., Moorhead, 3 July 1980, on American elm (1)

MISSISSIPPI: Adams Co., Natchez, 15 June 1909, 17 June 1909, 19 June 1909, 21 June 1909, in Spanish moss, E. S. Tucker collector (2, 1, 1, 5)

NEW HAMPSHIRE: Carroll Co., Chocorua, altitude 3470 ft., G. H. Dieke Collection (1); Hillsborough Co., Manchester, 18 May, 22 May, 9 June, 15 June, W. S. Abbott 1932 thru Bridwell (1, 1, 1, 1)

WISCONSIN: Milwaukee Co., 30 July 1900, F. Rauterberg collector (1); Milwaukee Co., F. Knab Collection (1)

Calligrapha spiraea (Say 1826) (Figure 1n)

Canada: Ontario (Wheeler and Hoebeke 1979; Bousquet 1991; Riley et al. 2003), Quebec (Mullins 1976; reported as dubious by Riley et al. 2003). U.S.A.: Arkansas (Riley et al. 2003), Connecticut (Britton 1920; Leng 1920; Wilcox 1972; Mullins 1976; Downie and Arnett 1996; Riley et al. 2003), District of Columbia (Riley et al. 2003), Kansas (Douglass 1929; Riley et al. 2003), Maine (Wilcox 1972, 1975; Downie and Arnett 1996; Riley et al. 2003), Maryland (Schroder et al. 1996; Riley et al. 2003), Michigan (Brown 1945; Wilcox 1972, 1975; Mullins 1976; Wheeler and Hoebeke 1979; Downie and Arnett 1996; Riley et al. 2003), Missouri (Say 1826; Mullins 1976; Riley and Enns 1979; Riley et al. 2003), New York (Wheeler and Hoebeke 1979; Riley et al. 2003), North Carolina (Brimley 1938; Mullins 1976; Wheeler and Hoebeke 1979; Riley et al. 2003), Ohio (Mullins 1976; Downie and Arnett 1996; Riley et al. 2003), Pennsylvania (Say 1826; Wilcox 1972, 1975; Mullins 1976; Wheeler and Hoebeke 1979; Downie and Arnett 1996; Riley et al. 2003), Rhode Island (Sikes 1999), Virginia (Mullins 1976; Wheeler and Hoebeke 1979; Riley et al. 2003), West Virginia (Clark 2000; Riley et al. 2003).

ILLINOIS: North Illinois, F. Knab Collection (1)

IOWA: Johnson Co., Iowa City, Wickham collector (1)

WISCONSIN: Milwaukee Co., Milwaukee, Milwaukee Public Museum (1); Washburn Co., Spooner, 26 May 1949, S. I. Parfin collector (1); Wisconsin, F. Knab Collection (1)

Calligrapha suturella Schaeffer 1933 (Figure 1o)

U.S.A.: New Hampshire (Schaeffer 1933). Gómez-Zurita et al. (2004) have used genetic data to support the elevation to specific status of this taxon, originally described as a local variety of *C. multipunctata* (Say 1824). Together with the re-description of the species, a number of new localities and new province and State records were provided which are reproduced below.

MANITOBA: Franklin, 1649 feet, 17 July 2002, on *Salix bebbiana*, D. J. Funk collector (3)

QUEBEC: L'Amiante, Saint-Joseph-de-Coleraine, 27 July 2000, on *Salix bebbiana*, D. J. Funk collector (1); Lac-Saint-Charles, 26 July 2000, on *Salix bebbiana*, D. J. Funk collector (1);

MAINE: Cumberland Co., Portland 18 June 2003, on *Salix bebbiana*, D. J. Funk (2); Kennebec Co., Sidney 6 June 2002, on *Salix bebbiana*, D. J. Funk collector (1); Kennebec Co., Sidney 20 June 2003, on *Salix bebbiana*, D. J. Funk collector (1); Somerset Co., Moose River 25 July 2000, on *Salix bebbiana*, D. J. Funk collector (1)

MASSACHUSETTS: Berkshire Co., Hinsdale, 21 August 1898 (1); Hampden Co., Ludlow, 22 June 1902 (1); Hampden Co., Wilbraham, J. O. Martin collector (1); Massachusetts (1)

MICHIGAN: Baraga Co., 10 miles W Three Lakes, 7 June 1982, David R. Smith collector (1); lower peninsula, Ogemaw Co., Rt. I-75, 836 feet), 22 July 2002, on *Salix bebbiana*, D. J. Funk collector (1); Agriculture Collection Michigan, 1891, C. F. B., F. Knab collector 1918 (1)

MINNESOTA: Aitkin Co., 3 miles S McGrath, 3 July 1984, Downie and Wappes collector (1); Becker Co., Itasca St. Pk. Area, 28-29 June 1984, Downie and Wappes collector (1); Kanabec Co., Mora, 25 August 1907, R. A. Vickery collector (2); St. Anthony Pk., 9 June 1907 (1)

NEW HAMPSHIRE: Hillborough Co., Manchester, 16 June, 25 June and 5 July 1932, W. S. Abbott collector (4); Strafford Co., Milton, 3 July 1897, F. Knab Collection 1918 (3); Squam Lake, F. Knab Collection 1918 (1)

NEW YORK: Van Cortland Park, Charles Schaeffer coll. (1)

VERMONT: Windham Co., Brattleboro, spring 1894, F. Knab Collection 1918 (1)

WISCONSIN: Wood Co., Cranmoor, 26 August 1909, C. W. Hooker coll. (1)

Calligrapha sylvia Stal 1860 (Figure 1o)

U.S.A.: Arizona (Linell 1896; Wilcox 1972, 1975; Riley et al. 2003), New Mexico (Townsend 1895; Riley et al. 2003). Mexico (Jacoby 1880-1888; Leng 1920; Linell 1896; Wilcox 1972, 1975; Blackwelder 1982).

Note: This new record has to be considered provisional, since it seems to be from an intercepted specimen on the border between Mexico and the US. However, the confirmed presence of the species in neighboring areas suggests that it could be naturally present in Texas too.

TEXAS: El Paso Co., El Paso, 1 July 1942, with mustard greens from Mexico (1)

Calligrapha verrucosa (Suffrian 1858) (Figure 1p)

Canada: Alberta (Brown 1945; Robertson 1966; Bousquet 1991; Riley et al. 2003), British Columbia (Brown 1945; Robertson 1966; Hatch 1971; Wilcox 1972, 1975; Bousquet 1991; Riley et al. 2003), Manitoba (Brown 1945; Robertson 1966; Wilcox 1972, 1975; Bousquet 1991; Riley et al. 2003), Northwest Territories (Bousquet 1991; Riley et al. 2003), Ontario (Bousquet 1991; Riley et al. 2003), Saskatchewan (Brown 1945; Robertson 1966; Bousquet 1991; Riley et al. 2003). U.S.A.: California (Riley et al. 2003), Idaho (Hatch 1971; Riley et al. 2003), Montana (Leng 1920; Hatch 1971; Wilcox 1972, 1975; Riley et al. 2003), Nebraska (Riley et al. 2003), Nevada (Riley et al. 2003), Oregon (Hatch 1971; Wilcox 1972; Riley et al. 2003), Utah (Riley et al. 2003), Washington (Hatch 1971; Riley et al. 2003), Wyoming (Lawson 1976; Riley et al. 2003).

ALASKA: Fairbanks North Star Co., Fairbanks, 16 July 1952 (2); Fairbanks North Star Co., Fairbanks, 23 May 1966, on *Salix spp.*, Joan Foote and Les Viereck collectors (2); Fort Yukon, 3 July 1953, R. I. Sailer (1)

Calligrapha vicina Schaeffer 1933 (Figure 1p)

Canada: New Brunswick (Bousquet 1991; Riley et al. 2003), Ontario (Brown 1945; Robertson 1966; Bousquet 1991; Riley et al. 2003), Quebec (Brown 1945; Robertson 1966; Bousquet 1991; Riley et al. 2003). U.S.A.: Maryland (Cavey 1994; Downie and Arnett 1996; Riley et al. 2003), New York (Schaeffer 1933; Brown 1945; Robertson 1966; Wilcox 1972, 1975; Downie and Arnett 1996; Riley et al. 2003), Pennsylvania (Riley et al. 2003).

CONNECTICUT: Connecticut, Blaisdell Collection (2)

MASSACHUSETTS: Hampden Co., Montgomery, 21 August 1897, F. Knab collector (1); Worcester Co., Southbridge, 3 May 1913, S. W. Bromley Collection (1)

OHIO: Ohio, C. F. B. collector (1)

VERMONT: Bennington Co., Roberts Collection (1); Chittenden Co., Burlington, May 1942, U. V. M. collector (1)

Zoogeography of Nearctic *Calligrapha*

The catalogue of *Calligrapha* species in North America north of Mexico currently includes 38 taxa, after establishing the synonymy for several subspecies pairs (Riley et al. 2001, 2003). The largest percentage (86.8%) corresponds to endemic forms for this part of the world, the only exceptions being species in a group that expands from Central America reaching the southernmost states in the United States (i.e., *C. dislocata, C. multiguttata, C. serpentina, C. sylvia* and *C. fulvipes*). The new distribution data presented here combined with the latest report on the distribution of the species in this genus (Riley et al. 2003) allows updating the data on endemicity of *Calligrapha* on a per country basis. The Canadian list of endemic *Calligrapha* includes the species *C. amator, C. tiliae,* and *C. virginea,* and the United States list the species *C. amelia, C. androwi, C. cephalanti, C. floridana,* and *C. wickhami*. The remaining species except for the above mentioned group expanding from Central America have been recorded in both countries. The highest diversity of *Calligrapha* can be found in the Northeast quadrant of North America, in the area around the Great Lakes (Figure 2).

An analysis of the ranges of distribution of all the North American species of *Calligrapha* helps establishing a tentative separation of groups according to their geographical distribution (Table 1, Figure 2). This separation follows in general terms two gradients: a longitudinal gradient most likely conditioned by the orography of the subcontinent, with the main mountain ranges following a North-South axis, and a latitudinal gradient possibly driven by climatic/ecological conditions. The first zonation distinguishes from west to east (i) a Pacific group limited eastward (less so to the north) by the Rocky Mountains, (ii) an Atlantic group not surpassing this mountain system to the west, and (iii) a Great Plains group distributed mainly in this geographical area, but spreading to the east and limited to the west by the Rockies (Table 1). The second possibly climatic or historical zonation includes (i) a Central American group, present only in the southernmost regions of North America, (ii) the endemic species from Florida, and (iii) a very rich group in the area surrounding the Great Lakes (Table 1). A group of a few trans-Nearctic species widely distributed from coast to coast could be included among these too. Areas where two or more geographical assemblages overlap, on the edges from the centers of maximum diversity of each group, show a corresponding relative increase in species richness. This is well exemplified by the North-South corridor from Manitoba to Texas, where the Atlantic and Pacific groups meet intersecting with the Great Plains group, and showing richer *Calligrapha* faunas than the adjacent regions (Figure 2). The observed distribution pattern of *Calligrapha* and the importance of the Cordilleras (particularly the Rocky Mountains and Sierra Nevada) in separating the two dominant groups, Pacific and Atlantic, is consistent with similar patterns observed for *Onychomys* grasshopper mice, *Gambelia* lizards, *Crotalus* rattlesnakes, *Agelenopsis* spiders, and several plants, among others (e.g., Riddle and Honeycut 1990; Orange et al. 1999; Pook et al. 2000; Hong, 2001; Ayoub and Riechert 2004). The effective barrier

TABLE 1. Grouping of *Calligrapha* species according to their distribution ranges in North America (north of Mexico).

Longitudinal			Latitudinal			
Pacific	Great Plains	Atlantic	Trans-Nearctic	Great Lakes	Central American	Florida
C. sigmoidea	*C. incisa*	*C. ignota*	*C. californica*	*C. alni*	*C. dislocata*	*C. cephalanti*
C. verrucosa	*C. praecelsis*	*C. knabi*	*C. multipunctata*	*C. suturella*	*C. multiguttata*	*C. floridana*
	C. rhoda	*C. rowena*	*C. philadelphica*	*C. alnicola*	*C. serpentina*	
		C. scalaris	*C. bidenticola*	*C. tiliae*	*C. sylvia*	
		C. confluens	*C. lunata*	*C. vicina*	*C. wickhami*	
		C. spiraea		*C. virginea*	*C. fulvipes*	
		C. amelia		*C. amator*		
		C. pnirsa		*C. apicalis*		
		C. androwi		*C. dolosa*		
				C. ostryae		
				C. pruni		

of the Cordilleras could be not only responsible for the spatial structuring of the group in North America, but for its diversification as well. However, it is important to retain the idea that the effect of geographical barriers in the case of non-generalist phytophagous beetles like *Calligrapha* could be indirect, the primary effect being on the actual host plants of the insects.

Latitudinal faunal structuring in North America, mainly related to climatic and the associated ecological gradients, has been analytically demonstrated for instance in mammals (Badgley and Fox 2000). At a different scale, a similar situation can be described for phytophagous specialist *Calligrapha*, where climate and ecology have a tight link through the distribution of the host plants. However, the observed latitudinal zonation in these beetles could be the effect of historical processes too, something that a phylogenetic analysis of genus can help to discern (Gómez-Zurita and collaborator, in preparation). The endemicity area of Florida could be related for instance to the prolonged insularization of this peninsula during the Pliocene, which has been proved effective to trigger the diversification of several animal groups (e.g., Gilbert 1987; Moler and Kezer 1993).

The Great Lakes area is particularly interesting for two reasons: species diversity and species ecology. The highest species diversity of the genus in North America occurs in this region, particularly in the Canadian provinces of Ontario and Quebec, resulting from the overlap of the two richest species groups, the so-called "Great Lakes" and the Atlantic groups, together with the trans-Nearctic species. We believe that the high species diversity in this region is related to climatic and idiosyncratic features of this particular area that provides with a variety of niches for the colonization and possibly diversification of *Calligrapha*. An interesting feature of the North American *Calligrapha sensu stricta* is that they have exploited a trophic niche different from the feeding selection of the other subgenera and the congeneric species in Central and South America. While the latter feed on grasses and herbaceous plants, most North American species feed on trees and shrubs from different botanical families, but typically found associated to streams and river banks (e.g., *Alnus, Betula, Cornus, Ostrya, Physocarpus, Salix, Tilia,* and *Ulmus*; Brown 1945). Interestingly, these plants are particularly abundant and have the center of their distribution precisely in the Great Lakes area and North Eastern North America (Little 1980; USDA, NRCS 2004*), where most species of *Calligrapha* are also found. This correlation is not surprising and is particularly accurate in some cases. The ninebark, *Physocarpus opulifolius* (Rosaceae), is the sole host-plant of *C. spiraea*, and the beetle has the same as the core distribution of the plant in North America (Figure 1n), which ranges from Quebec west to Michigan and south to Tennessee, although the plant reaches as isolated spots Eastern North Dakota and Kansas to the west and Northern Florida to the north (Wheeler and Hoebeke 1985; USDA, NRCS 2004*). *Tilia americana* var. *americana* (American Basswood; Tiliaceae) is restricted to the Northeastern quadrant of North America (Little 1980; USDA, NRCS 2004*). Three species of *Calligrapha*, including *C. amator* (Figure 1c), feed on this host and are present only in the plant center of distribution (Brown 1945). Similar situations can be described for *C. ignota* and their birch host *Betula lenta* (Betulaceae; possibly *B. papyrifera* too), *C. alni* (Figure 1a), *C. alnicola* (Figure 1b), *C. amelia* (Figure 1c), *C. apicalis* (Figure 1d), and *C. confluens* (Figure 1g) on the alders *Alnus incana americana* and *A. rugosa* (Betulaceae), all living exclusively in North Eastern North America. *C. scalaris* and *Ulmus americana* (American Elm; Ulmaceae), and *C. rhoda* with *Corylus americana* (American Hazelnut; Betulaceae), are all only present in the Eastern half of North America. The trans-Nearctic *Calligrapha* (*sensu stricta*) species also conform to the expected correlated distribution with the host plant. So, *Cornus sericea* (= *C. stolonifera*; Dogwood; Cornaceae) and *Salix bebbiana* (Bebb's Willow; Salicaceae), the preferred respective host plants of *C. philadelphica* and *C. multipunctata*, are also distributed throughout North America (Brown, 1945; USDA, NRCS 2004*).

FIGURE 2. *Calligrapha* species numbers in North American provinces and states. Thick lines roughly demarcate faunistic groups in the genus according to their geographic distribution.

Calligrapha stands out among leaf beetles because it includes several parthenogenetic species, otherwise very unusual among the Chrysomelidae (Brown 1945; Robertson 1966; Cox 1996; Gómez-Zurita et al. 2004). It is noteworthy that all asexual species in *Calligrapha* belong to the "Great Lakes" group and have typically restricted ranges (with the possible exceptions of *C. alnicola* and *C. suturella*; Figures 1b and 1o). This example of geographical parthenogenesis is however difficult to reconcile with current hypotheses relating this reproductive mode with better colonizing abilities, highest adaptability through generalist behavior or clonal microadaptation, and/or advantages on environments with reduced biotic (particularly parasitic) interactions (Haag and Ebert 2004, and references therein). The parthenogenetic *Calligrapha* species coexist in close sympatry with several other sexually reproducing taxa (Brown 1945) and moreover we have hypothesized that interspecific hybridization might be the mechanism behind the origin of asexuality in *Calligrapha* (Gómez-Zurita et al. 2004), not existing reasons a priori suggesting interspecific hybridization to occur following any geographical pattern. Again, phylogenetic studies are needed to provide sound answers to these questions relevant for the biogeography, systematics and evolution of such an remarkable genus, *Calligrapha* (Gómez-Zurita and collaborator, in preparation).

Descriptive studies like this paper, aimed to resolve basic questions about the distribution of organisms in a particular geographical region, are critical to formulate meaningful hypotheses to be tested on a phylogenetic or ecological framework. The potential for information held at Museums and research institutions even for regions and taxa relatively well known, as for the leaf beetles from North America, is still enormous. A facilitated access to these resources and ensuring conditions for their preservation prove very important to advance our understanding of the World's biodiversity.

Acknowledgments

I express my gratitude to Alexander Konstantinov from the National Museum of Natural History (Smithsonian Institution, Washington, DC) for the loan of the *Calligrapha* specimens for study. Thanks also to Daniel Duran, Charles and Susan Staines, and especially to Daniel Funk (Vanderbilt University, Tennessee) for collecting some of the specimens reported here. Thanks also to Anabela Cardoso for reading a preliminary version of this work and for her suggestions and ideas to improve it. Two anonymous referees provided very useful comments to further improve this work.

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Received 12 January 2004
Accepted 7 March 2005

Weight-carrying Ability and Caching Behavior of Gray Jays, *Perisoreus canadensis*: Adaptations to Boreal Winters

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Rogers, Lynn L. 2005. Weight-carrying ability and caching behavior of Gray Jays, *Perisoreus canadensis:* Adaptations to boreal winters. Canadian Field-Naturalist 119(1): 101-104.

During 16 August to 21 September 1984, I determined how Gray Jays *(Perisoreus canadensis)* carried flight-loads of different weights. Three individually identifiable Gray Jays weighing 60, 68, and 80 grams, used their bills to carry flight-loads weighing up to 33 percent of bodyweight but transferred heavier flight-loads from their bills to their feet 1-2 meters after takeoff. They had difficulty carrying flight-loads over 57 percent of bodyweight, and none attempted to carry flight-loads over 66 percent of bodyweight. By using their feet to bring heavy flight-loads closer to the center of lift, Gray Jays can carry heavier loads of meat, relative to body weight, than can Common Ravens *(Corvus corax)* which compete with Gray Jays at carcasses in winter and which do not carry objects with their feet. During 1969-2003, year-round observations near the southern edge of the Gray Jay range in northeastern Minnesota showed that caching behavior begins in August, continues over-winter, and ends at the onset of insect activity and green-up in early May. Gray Jays' propensity to approach larger animals, including people, may not indicate unwariness but rather a superior ability and willingness to assess risks and food benefits. In the boreal forest in winter, risk of starvation is greater and risk of predation is lower than in relatively food-rich ecoregions farther south.

Key Words: *Perisoreus canadensis*, scavenging, food cache, flight-load, feet, competition, boreal forest, risk assessment, saliva, survival strategy, Minnesota.

Gray Jay biology has been extensively researched, and their abilities to carry meat scraps in their feet and glue food caches to branches have been reported (Brewster 1937; Bock 1961; Dow 1965; Stirling 1968; Gill 1974; Bent 1946; Strickland and Ouellet 1993). I describe how Gray Jays carry flight-loads of different weights and report additional observations on scavenging and caching behaviors in northeastern Minnesota near the southern edge of their range.

Methods and Materials

During 1969-2003, I made year-round observations of Gray Jays feeding on suet or on White-tailed Deer *(Odocoileus virginianus)* that were killed by vehicles or Timber/Gray Wolves *(Canis lupus)* near Ely, Minnesota. During 16 August to 21 September 1984, I determined weights of suet pieces carried off by three Gray Jays that were individually identifiable by their weights and by feather irregularities. I placed the suet pieces on a Hanson 500-g scale. When a Gray Jay landed and carried off one of the pieces (Figure 1), I recorded the weight of the jay, the weight of the piece it selected, and how the jay carried it.

Results

Three Gray Jays, weighing 60, 68, and 80 g, used their bills to carry pieces of suet weighing up to 33 percent of bodyweight but transferred heavier loads (42-66 percent of bodyweight) from their bills to their feet 1-2 meters after takeoff (Table 1). They had difficulty carrying flight-loads over 57 percent of bodyweight, and none attempted to carry pieces over 66 percent of bodyweight.

FIGURE 1. The 500-gram scale used to weigh Gray Jays and suet. Photo by Lynn Rogers.

The Jays were successful in only 2 of 12 attempts to carry pieces of suet weighing 57-66 percent of bodyweight (Table 1). In five attempts to fly with pieces weighing 58-64 percent of bodyweight, they dropped them while attempting to transfer them from their bills to their feet (Table 1). These dropped into deep grass and were abandoned. An 80-g Jay twice dropped a 46-g piece (58 percent of bodyweight) during transfers but on the third attempt reached an altitude of 2 meters and maintained level flight for over 50 meters. A 68-g Jay carried a 43-g piece of suet (63 percent of bodyweight) plus 2 g of stomach contents totaling 66 percent of bodyweight. It leaped into flight from a point 1.1 meter high, lost about a meter of altitude while transferring the load from its bill to its feet, and then flew close to the ground with labored flight. In three other instances, Jays used their bills to lift pieces of suet weighing 57-60 percent of bodyweight but did not attempt to fly off with them.

With pieces of suet too heavy to fly off with, Jays held them with their feet, and used their bills to twist off small pieces. Amounts ingested per visit increased as the suet aged and softened. For example, the Jays ingested an average of only 0.4 g per visit (n = 15 visits) from a fresh piece of hard suet on 19 August, but as the suet softened over the next 8 days, average amount ingested increased to 0.875 g per visit on 24 August (n = 8 visits), 1.45 g per visit on 25 August (n = 11 visits), and 1.5 g on 27 August (n = 6 visits). Each Jay weighed 1-3 g more after the initial 1-3 visits, indicating that they were retaining the initial 1-3 g for immediate digestion and flying off and storing what they ingested in subsequent visits.

Gray Jays were common in the study area yearround. However, I observed no scavenging or caching of suet from the onset of green-up and insect activity in early May through the end of July. When caching behavior resumed in August, they used their sticky saliva to glue caches to branches (Figure 2).

Discussion

With the exception of shrikes [*Lanius* spp.] (Sibley 2001), I found no report of other passerines, including other corvids, carrying food or other objects with their feet. This ability to carry food with their feet aids competition for meat scraps at carcasses. By using their feet to bring flight-loads closer to their center of lift, Gray Jays can carry heavier loads, relative to bodyweight, than can Common Ravens, which do not carry food in their feet. For example, if ravens weigh 1200 g, as listed by Dunning (1984), an adult raven that carried a 237-g piece of meat to a tree carried only 20 percent of its

TABLE 1. Flight-loads carried by Gray Jays in their bills or feet in northeastern Minnesota, 16 August to 21 September 1984.

Bird weight (grams)	Load weight (grams)	Percent of bodyweight	Means of carrying	Comments
60-80[1]	11	14-18%	Bill	Flew easily.
80	14	18%	Bill	Flew easily.
60-80[1]	14	18-23%	Bill	Flew easily carrying a Deer Mouse *(Peromyscus maniculatus).*
80	26	33%	Bill	Jay rose 5 m at 45 degrees.
80	26	33%	Bill	Level flight but dropped food upon entering dense foliage.
60	25	42%	Feet	
60-80[1]	9	36-48%	Feet	Ascended 60 degrees to fly over a 3-meter obstacle.
60-80[1]	38	48-63%	Feet	Rose 3 m over a distance of 30 m.
68	36	53%	Feet	Flew easily.
80	42	53%	Feet	Flew easily.
80	43	54%	Feet	Level flight and glide.
80	45	57%	—	Lifted food with bill but did not attempt to fly with it.
80	46	58%	Feet	Dropped food 1-2 m after takeoff in first 2 attempts. Third attempt successful.
68	40	59%	—	Lifted food with bill but did not attempt to fly with it.
68	41	60%	—	Lifted food with bill but did not attempt to fly with it.
80	49	61%	—	Dropped food <1 m after takeoff during transfer from bill to feet and abandoned it.
68	43	63%[2]	Feet	Level flight low to ground.
68	43	63%	—	Dropped food <2 m after takeoff during transfer from bill to feet and abandoned it.
80	51	64%	—	Dropped food 1.5 m after takeoff during transfer from bill to feet and abandoned it.

[1]Did not determine which of the three jays took the food, so the weight range of the three was used to calculate percentage of body weight.

[2]This Jay ingested 2 g of suet in an earlier visit to the scale and still weighed 2 g heavier when carrying the 43 g, making the total load 45 g of suet—over 66% of body weight.

FIGURE 2. A sunflower seed cached on the tip of a Red Pine *(Pinus resinosa)* branch near Ely, Minnesota, in late September. Gray Jays use sticky saliva to encase food and glue it where it will remain above snow cover. It is unknown whether this encasement also preserves freshness, protects against mold and bacteria, and/or deters insects and other cache-robbers by reducing odors, making caches distasteful, or disguising them as inedible items. Photo by Lynn Rogers.

bodyweight, and an adult raven that dropped a 624-g piece of meat 1-2 meters after leaping into flight was unable to carry 52 percent of bodyweight (unpublished data). By comparison, Gray Jays fly buoyantly carrying that percentage of bodyweight in their feet (Table 1). Further, a 79.5-g male carried a 72.9-g piece of bread (92 percent of bodyweight) 20 meters in its feet before dropping it in Algonquin Provincial Park, Ontario (Strickland and Ouellet 1993).

Gray Jays opportunistically scavenge ungulate carcasses that have been opened by carnivores, ravens, eagles, and other scavengers strong enough to penetrate tough skin. Gray Jays' propensity to approach larger animals, including people, may not indicate unwariness but rather a superior willingness and ability to assess risks and food benefits. In the boreal forest in winter, risk of starvation is greater and risk of predation is lower than in relatively food-rich ecoregions farther south. For example, compared with the eastern deciduous forest, the boreal forest has longer winters, lower primary productivity, lower animal biomass (especially in winter when most birds have migrated), and lower diversity and abundance of predators (Odum 1971). Thus, selective pressures in the boreal forest, especially in winter, may favor more intensive assessment of potential food sources rather than the more cautious behavior typical of migratory birds of the boreal forest and of residents of ecoregions with more food and less extreme winters. Gray Jays' ability to carry heavy flight-loads in their feet helps minimize exposure to predators and competitors at carcasses.

Gray Jays' habit of using sticky saliva to encase their food caches and glue them to branches (Figure 2) enables them to place caches where they will remain above snow cover (Dow 1965). In northeastern Minnesota, caching begins in August, leaving 3-4 months for spoilage and cache-robbing before winter. Temperatures in Ely, Minnesota, average 18°C in August, 13°C in September, 6°C in October, and –4°C in November. Further study is needed to determine whether encasing caches in saliva preserves freshness, protects against mold and bacteria, and/or deters insects and other cache-robbers by reducing odors, making caches distasteful, or disguising them as inedible items.

The winter diet is not entirely cached food and carrion (Strickland and Ouellet 1993). On 26 January 2002, a Gray Jay ingested fruticose lichens from the trunk of a Paper Birch tree *(Betula papyrifera).* I found no previous report of feeding on lichens, although eating or caching fungi has been reported (Sutherland and Crawford 1979, Strickland and Ouellet 1993).

Acknowledgments

I thank A. J. Erskine, D. Strickland, and an anonymous reviewer for helpful comments.

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Received 13 September 2004
Accepted 21 February 2005

Premières mentions et répartition de la Salamandre sombre du Nord, *Desmognathus fuscus,* sur la rive nord du fleuve Saint-Laurent, au Québec

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Desroches, J.-F., et D. Pouliot. 2005. Premières mentions et répartition de la Salamandre sombre du Nord, *Desmognathus fuscus,* sur la rive nord du fleuve Saint-Laurent, au Québec. Canadian Field-Naturalist 119(1): 105-109.

La Salamandre sombre du Nord (*Desmognathus fuscus*) est une espèce qui a fait l'objet de plusieurs inventaires au Québec étant donné qu'elle y est à la limite nord de sa répartition. Nous rapportons les premières observations de cette espèce au nord du fleuve Saint-Laurent, depuis Trois-Rivières, à l'ouest, jusqu'à Cap-Tourmente, vers l'est. Ces mentions ont été faites de 1987 à 2003, dans 20 sites. La majorité des sites où fut découverte la Salamandre sombre du Nord sont des ruisseaux et des résurgences d'eau.

Mots-Clés: *Desmognathus fuscus*, Salamandre sombre du Nord, aire de distribution, répartition, habitat, Québec.

The Northern Dusky Salamander (*Desmognathus fuscus*) has been searched for extensively at its presumed northern range limit in Québec, south of the St-Lawrence River. We report the first records of this species north of the St-Lawrence River, from Trois-Rivières, in the west, to Cap-Tourmente in the east. These observations were made between 1987 and 2003, at 20 sites. Most of the sites where the Northern Dusky Salamander was found are streams and seepages.

Key Words: *Desmognathus fuscus*, Northern Dusky Salamander, distribution, habitat, Québec.

La Salamandre sombre du Nord (*Desmognathus fuscus*) se retrouve à la limite nordique de sa répartition dans le sud de la province de Québec (Cook 1984). Les mentions historiques les plus nordiques de l'espèce ont été faites à Lac Trois-Saumons, comté de l'Islet (47°08'N, 70°12'O) et à Saint-André, comté de Kamouraska (47°38'N, 69°40'O), deux localités situées sur la rive sud du fleuve Saint-Laurent (Denman 1963). Bleakney (1958) avait émis l'hypothèse que le fleuve Saint-Laurent avait constitué une barrière à la dispersion de la Salamandre sombre du Nord. Bider et Matte (1991), dans la version détaillée de l'Atlas des amphibiens et des reptiles du Québec, mentionnent : «Puisque cette salamandre est activement recherchée par plusieurs herpétologistes, on peut donc penser que sa répartition décrite ici est assez complète». Or, en 1987, nous avons eu la surprise de la découvrir pour la première fois sur la rive nord du Saint-Laurent

En 1987, JFD trouva quelques spécimens de l'espèce à Boischatel, à l'est de Québec, dans des eaux de résurgence sur les rives abruptes de la rivière Montmorency. Ils ont été formellement identifiés par lui-même en 1990, puis localisés approximativement dans l'Atlas des amphibiens et reptiles du Québec (Bider et Matte 1994). Des recherches visant à découvrir d'autres populations furent entreprises dès 1996 et 1998 par les auteurs. En 2001, une Salamandre sombre du Nord fut trouvée par DP à la rivière Jean-Larose, près du mont Sainte-Anne, à 28 km au nord-est des mentions faites à la rivière Montmorency. Cette découverte ouvrait la porte à la possibilité que cette salamandre puisse être plus répandue que prévu dans la région. Un inventaire spécifique fut ainsi réalisé en 2002. Il avait comme objectif de documenter la répartition de l'espèce sur la rive nord du Saint-Laurent, et d'obtenir une idée générale de l'habitat de cette espèce à la limite nordique de sa répartition.

Méthodologie

L'inventaire de 2002 visant la découverte de la Salamandre sombre du Nord à d'autres endroits sur la rive nord du Saint-Laurent a été réalisé dans 40 nouveaux sites. Les sites ont été localisés préalablement sur des cartes topographiques 1: 50 000 ou choisis au hasard sur le terrain. La méthodologie utilisée est similaire à celle de Weller (1977) et consiste en des recherches variant de 15 à 60 minutes dans les ruisseaux et sur les rives de cours d'eau, en soulevant les débris au sol. La présence et l'absence de la Salamandre sombre du Nord, le nombre d'individus, leur stade de développement, l'habitat, la date et la localisation au GPS en NAD83 ont été notés à chacun des sites visités (annexe I). Les sites situés à proximité, mais séparés par un secteur où l'habitat est moins propice, ont été considérés et cartographiés séparément malgré qu'ils puissent concerner le même cours d'eau. Au moins un spécimen a été récolté à la plupart des sites, sauf lorsque ceux-ci étaient situés à proximité l'un de l'autre. Les salamandres récoltées ont été déposées au Musée canadien de la nature sous les numéros CMNAR 35713-35729.

Résultats et discussion

De 1987 à 2003, la présence de la Salamandre sombre du Nord a pu être confirmée dans 20 sites situés

sur la rive nord du Saint-Laurent. Cinq d'entre eux ont été découverts de 1987 à 2001, 13 durant l'inventaire spécifique de 2002, et deux durant des recherches supplémentaires effectuées en 2003 plus à l'ouest. Ces 20 sites s'étalent d'ouest en est de la rivière Saint-Maurice, à Trois-Rivières, jusqu'à Cap-Tourmente (figure 1). Les sites situés aux extrémités (ouest et est) sont séparés par 160 km. Toutes les observations ont été faites dans les contreforts du Bouclier Canadien, dans le domaine de l'Érablière à Tilleul, où l'altitude moyenne varie de 55 à 116 m (Robitaille et Saucier 1998). Au sein de cette aire, la Salamandre sombre du Nord semble en général localisée à des secteurs où le microhabitat est propice: eaux de suintement, zones vaseuses avec mousses par endroits et bordure des ruisseaux. Le long des grandes rivières où on la retrouve, comme les rivières Saint-Maurice, Batiscan et Montmorency, elle fut retrouvée dans des eaux de ruissellement localisées et habituellement situées à quelque distance de la rivière (de quelques mètres à plus de 300 m), et non de façon régulière sur les rives des cours d'eau.

Les habitats dans lesquels fut trouvée la Salamandre sombre du Nord sont : les ruisseaux (< 3m de largeur) (59,0 % des sites), les eaux de résurgence (36,4 %), et un fossé forestier sans eau (4,6 %). Ces habitats concordent avec ceux décrits dans la littérature : habitats forestiers aquatiques ou semi aquatiques, souvent abondante aux endroits où se retrouvent des résurgences d'eau et le long des petits ruisseaux forestiers bordés de roches ou autres abris (Bishop 1941; Petranka 1998).

La plus forte proportion de ruisseaux peut représenter un biais. En effet, l'espèce semble assez typique des eaux de résurgence, mais ces milieux sont difficilement repérables sur des cartes à l'échelle 1: 50 000, comparativement aux cours d'eau permanents qui sont bien visibles.

Au Canada, la Salamandre sombre du Nord est une espèce associée aux Appalaches (Bleakney 1958). Nos résultats démontrent cependant qu'elle semble bien établie sur la rive nord du Saint-Laurent, dans les contreforts du Bouclier Canadien. Comment l'espèce s'y est-elle rendue? À quel endroit a-t-elle traversé le fleuve Saint-Laurent? La topographie du territoire porte à croire que ce fut dans le secteur de la ville de Québec, et vraisemblablement à partir de l'embouchure de la rivière Chaudière (rive sud du Saint-Laurent, en bordure du pont de la route 73) qu'elle aurait franchi le fleuve, tel que proposé par Bider et Matte (1994). La Salamandre sombre du Nord se retrouve dans la rivière Chaudière et a pu traverser le fleuve à cet endroit, où la largeur de ce dernier est plus étroite (moins de 1 km) qu'aux autres secteurs (2 km et plus). De plus, à cet endroit, les Appalaches se rendent à proximité du Saint-Laurent, ce qui n'est pas le cas plus à l'ouest où une large bande de la vallée du Saint-Laurent sépare les Appalaches du fleuve.

Suite à son arrivée sur la rive nord, la Salamandre sombre du Nord se serait ensuite répandue vers l'ouest, dans le Bouclier Canadien, pour se répandre jusque dans la région de Trois-Rivières, quelques 115 km plus à l'ouest. Vers l'est, il semble que sa répartition s'arrête aux environs du Cap-Tourmente, où l'altitude devient plus importante et la topographie plus accidentée. La végétation y change également, passant du domaine de l'Érablière à Tilleul à celui de la Sapinière à Bouleau jaune (Robitaille et Saucier 1998). D'ailleurs, ce secteur constitue la limite de répartition nord-est de plusieurs espèces végétales et animales, dont certains amphibiens et reptiles (Cook 1984). On ignore si la Salamandre sombre du Nord s'est répandue vers le nord mais les recherches effectuées ces dernières années n'ont pas permis de la repérer. Le secteur situé à l'ouest de Trois-Rivières, situé lui aussi dans le domaine de l'Érablière à Tilleul, semble particulièrement propice, mais à cet endroit la vallée du Saint-Laurent est présente sur une bande plus large et le Bouclier Canadien se retrouve donc plus au nord. Nos recherches effectuées plus à l'ouest dans le Bouclier Canadien, dans les Laurentides au nord de Montréal et en Outaouais, n'ont pas permis de trouver de Salamandres sombres du Nord mais seulement la Salamandre à deux lignes (*Eurycea bislineata*).

Perspectives

La découverte de la Salamandre sombre du Nord sur la rive nord du Saint-Laurent ouvre la porte à la possibilité que certaines espèces d'amphibiens, notamment les salamandres, soient répandues plus largement que l'on croit au Québec, et notamment sur la rive nord. En effet, la présence de cette espèce sur la rive nord du Saint-Laurent était ignorée jusqu'en 1990 (année où les premiers spécimens furent identifiés), malgré le fait que les salamandres de ruisseaux (la Salamandre sombre du Nord, la Salamandre à deux lignes et la Salamandre pourpre (*Gyrinophilus porphyriticus*) aient fait l'objet de quelques inventaires professionnels au Québec (Bider et Matte 1991; Pendlebury 1973; Bleakney 1958). Il apparaît possible que la Salamandre sombre du Nord soit encore plus répandue sur la rive nord du Saint-Laurent, de même que sur la rive sud vers l'est. Des inventaires spécifiques réalisés dans le futur pourraient permettre de tester cette hypothèse.

Remerciements

Les auteurs remercient tous ceux qui ont participé aux travaux de terrain : Daniel Banville, Josiane Bergeron, Joël Bonin, Nathalie Côté, Benoit Couture, Frédérick Desroches, Sébastien Desroches, Ian-Erik Gosselin, Isabelle Picard, Martin Savard et Vicky Tremblay. Ils remercient également Frederick W. Schueler, pour ses commentaires sur la version préliminaire du texte, de même que Mario Darsigny pour la réalisation de la carte de l'aire d'étude et de la localisation des sites.

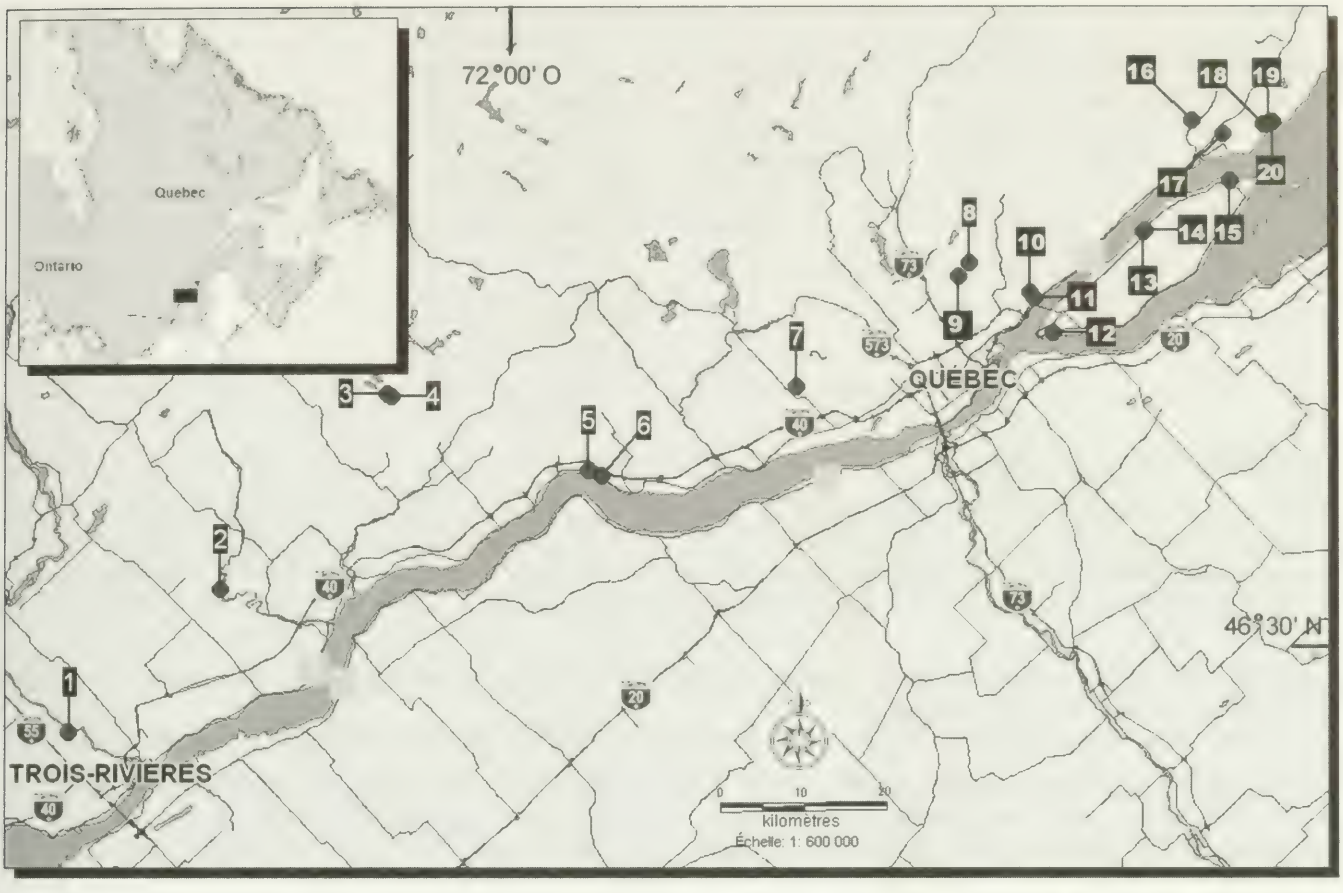

FIGURE 1. Localisation de l'aire d'étude au Québec (en médaillon) et des 20 sites où fut trouvée la Salamandre sombre du Nord sur la rive nord du Saint-Laurent, de 1987 à 2003.

1. Trois-Rivières, MRC de Francheville. 46°23'35"N; 72°38'58"O.
2. Saint-Narcisse, MRC de Francheville. 46°33'14"N; 72°24'59"O.
3. Municipalité de paroisse de Saint-Alban, MRC de Portneuf. 46°46'14"N; 72°09'50"O.
4. Municipalité de paroisse de Saint-Alban, MRC de Portneuf. 46°46'04"N; 72°09'25"O.
5. Municipalité de Cap-Santé, MRC de Portneuf. 46°41'36"N; 71°50'33"O.
6. Municipalité de Cap-Santé, MRC de Portneuf. 46°41'17"N; 71°49'18"O.
7. Municipalité de paroisse de Saint-Augustin-de-Desmaures, MRC de la Communauté Urbaine de Québec. 46°47'19"N; 71°31'08"O.
8. Charlesbourg, MRC de la Communauté Urbaine de Québec. 46°55'35"N; 71°14'54"O.
9. Charlesbourg, MRC de la Communauté Urbaine de Québec. 46°54'44"N; 71°16'00"O.
10. Boischatel, MRC de la Côte-de-Beaupré. 46°53'45"N; 71°09'07"O.
11. Boischatel, MRC de la Côte-de-Beaupré. 46°53'25"N; 71°08'47"O.
12. Sainte-Pétronille, MRC de l'Île-d'Orléans. 46°51'10"N; 71°06'55"O.
13. Sainte-Famille, MRC de l'Île-d'Orléans. 46°57'49"N; 70°58'24"O.
14. Sainte-Famille, MRC de l'Île-d'Orléans. 46°57'54"N; 70°58'17"O.
15. Saint-François, MRC de l'Île-d'Orléans. 47°01'12"; 70°50'16"O.
16. Mont-Sainte-Anne, MRC de la-Côte-de-Beaupré. 47°05'04"N; 70°54'01"O.
17. Saint-Joachim, MRC de la-Côte-de-Beaupré. 47°04'13"N; 70°51'03"O.
18. Cap-Tourmente, MRC de la-Côte-de-Beaupré. 47°04'55"N; 70°47'09"O.
19. Cap-Tourmente, MRC de la-Côte-de-Beaupré. 47°04'59"N 70°46'42"O.
20. Cap-Tourmente, MRC de la-Côte-de-Beaupré. 47°05'05"N; 70°46'16"O.

Lesroutes provincials 20, 40, 55, 73, et 573 sont inclues.

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Received 16 February 2004
Accepted 17 February 2005

Annexe I. Détails sur les localités et les salamandres observées

Chaque donnée est présentée de la manière suivante : # du site (voir la figure 1), nom de la municipalité, nom de la MRC (municipalité régionale de comté), localisation GPS en NAD 83, type d'habitat (eaux de résurgence, ruisseau) et présence ou non de Salamandre à deux lignes, date, nombre d'individus de Salamandres sombres du Nord observés et stade, nombre de spécimens récoltès, nom des observateurs, numéro de catalogue musée canadien de la nature (amphibiens et reptiles) CMNAR.

1. Les Vieilles-Forges, MRC de Francheville. 46°23'35"N; 72°38'58"O. Environ 100 m à l'ouest de la rivière Saint-Maurice. Habitat : Eaux de résurgence.
   20 juillet 2003 : 2 adultes (1 récolté), obs. : J.-F. Desroches, D. Pouliot, I. Picard et N. Côté. CMNAR 35278.
2. Saint-Narcisse, MRC de Francheville. 46°33'14"N; 72°24'59"O. Parc de la rivière Batiscan, environ 300 m à l'ouest de la rivière Batiscan. Habitat : Eaux de résurgence.
   20 mai 2003 : 1 subadulte, obs. : D. Pouliot et M. Savard.
   24 mai 2003 : 4 adultes (1 récolté) et 2 subadultes. : D. Pouliot et N. Côté. CMNAR 35729.
3. Municipalité de paroisse de Saint-Alban, MRC de Portneuf. 46°46'14"N; 72°09'50"O. 5ième rang, à 1,5 km au sud du lac en Cœur. Habitat : Eaux de résurgence. Présence de Salamandres à deux lignes.
   20 août 2002 : 5 adultes (1 récolté), JFD-02.10, obs. : D. Pouliot. CMNAR 35722.
4. Municipalité de paroisse de Saint-Alban, MRC de Portneuf. 46°46'04"N; 72°09'25"O. 5ième rang, à 1,5 km au sud du lac en Cœur. Habitat : ruisseau.
   20 août 2002 : 2 adultes, obs. : D. Pouliot.
5. Municipalité de Cap-Santé, MRC de Portneuf. 46°41'36"N; 71°50'33"O. 2,3 km à l'est de Portneuf, au nord de la route 138. Habitat : ruisseau. Présence de Salamandres à deux lignes.
   29 juillet 2002 : 1 adulte (récolté) et 1 jeune, JFD-02.17, obs. : D. Pouliot. CMNAR 35725.
6. Municipalité de Cap-Santé, MRC de Portneuf. 46°41'17"N; 71°49'18"O. Ruisseau André-Jacques, 2,8 km au nord-ouest de Cap-Santé, entre l'autoroute 40 et la route 138. Habitat : ruisseau. Présence de Salamandres à deux lignes.
   22 juillet 2002 : 5 adultes (1 récolté) et 1 jeune (récolté), JFD-02.19, obs. : D. Pouliot. CMNAR 35727.
7. Municipalité de paroisse de Saint-Augustin-de-Desmaures, MRC de la Communauté Urbaine de Québec. 46°47'19"N; 71°31'08"O. 1,3 km à l'est de la route 367. Habitat : ruisseau.
   9 août 2002 : 4 adultes (1 récolté), JFD-02.18, obs. : D. Pouliot. CMNAR 35726.
8. Charlesbourg, MRC de la Communauté Urbaine de Québec. 46°55'35"N; 71°14'54"O. Secteur du lac Des Roches. Habitat : fossé forestier.
   31 mai 1998 : 1 adulte, obs. : J.-F. Desroches et F. Desroches.
9. Charlesbourg, MRC de la Communauté Urbaine de Québec. 46°54'44"N; 71°16'00"O. Rivière Des Roches, en aval du lac Des Roches. Habitat : ruisseau. Présence de Salamandres à deux lignes.
   17 mai 1996 : 3 adultes, obs. : J.-F. Desroches.
   9 juillet 1997 : 1 subadulte, obs. : J.-F. Desroches.
   31 juillet 2002 : 1 adulte (récolté) et 1 jeune, JFD-02.16, obs. : D. Pouliot. CMNAR 35724.
10. Boischatel, MRC de la Côte-de-Beaupré. 46°53'45"N; 71°09'07"O. Rivière Montmorency en amont des chutes. Habitat : eaux de résurgence et ruisseau. Présence de Salamandres à deux lignes.
    1987 : plusieurs trouvées; 2 adultes (JFD-70) et 1 larve (JFD-55) récoltés, obs. : J.-F. Desroches. CMNAR 35715, 35714.
    23 avril 1990 : 2 adultes et quelques larves, obs. : J.-F.Desroches.
    13 octobre 1990 : 2 adultes, obs. : J.-F. Desroches.
    28 avril 1991 : 2 adultes, obs. : J.-F. Desroches.
    30 mai 1991 : 35 adultes et jeunes + 10 larves, obs. : J.-F. Desroches.
    17 avril 1992 : 1 adulte et 1 larve, obs. : J.-F. Desroches.
    9 février 1993 : 1 larve, obs. : J.-F. Desroches.

20 mars 1994 : 1 larve, obs. : J.-F. Desroches et F. Desroches.
3 mai 1995 : 2 adultes, obs. : J.-F. Desroches.
14 mars 1996 : 6 adultes (3 récoltés) et 2 larves, JFD-385, obs. : J.-F. Desroches et B. Couture. CMNAR 35717.
8 mai 1996 : 5 adultes et 3 jeunes, obs. : J.-F. Desroches.
17 mai 1997 : 5 adultes et 3 larves, obs. : J.-F. Desroches.
12 septembre 1999 : 2 adultes et 2 jeunes, obs. : J.-F. Desroches, J. Bonin et I. Picard.
18 octobre 1999 : 2 adultes, 1 jeune et 1 larve, obs. : J.-F. Desroches.
28 août 2002 : 4 adultes et 1 jeune, obs. : D. Pouliot et D. Banville.

11. Boischatel, MRC de la Côte-de-Beaupré. 46°53'25"N; 71°08'47"O. Rivière Montmorency au pied des chutes. Habitat : eaux de résurgence. Présence de Salamandres à deux lignes.
1990 : quelques trouvées, obs. : J.-F. Desroches.
8 juillet 1991 : 32 adultes et jeunes, obs. : J.-F. Desroches.
12 septembre 1999 : 2 adultes et 1 sub-adulte, obs. : J.-F. Desroches, J. Bonin et I. Picard.
18 octobre 1999 : 2 larves, obs. : J.-F. Desroches.

12. Sainte-Pétronille, MRC de l'Île-d'Orléans. 46°51'10"N; 71°06'55"O. Ruisseau Marie-Anne, secteur ouest de l'Île d'Orléans, 200 m au nord de la route 368. Habitat : ruisseau. Présence de Salamandres à deux lignes.
14 juin 2002 : 5 adultes et 2 jeunes, obs. : D. Pouliot, V. Tremblay, D. Banville et N. Côté.

13. Sainte-Famille, MRC de l'Île-d'Orléans. 46°57'49"N; 70°58'24"O. Secteur centre de l'Île-d'Orléans, 1,2 km au sud-ouest de Sainte-Famille, au nord de la route 368. Habitat : ruisseau. Présence de Salamandres à deux lignes.
14 juin 2002 : 1 adulte, obs. : D. Pouliot, V. Tremblay et N. Côté.

14 Sainte-Famille, MRC de l'Île-d'Orléans. 46°57'54"N; 70°58'17"O. Habitat : ruisseau. Présence de Salamandres à deux lignes.
25 juillet 2002 : 1 adulte, JFD-02.15, obs. : D. Pouliot. CMNAR 35723.

15. Saint-François, MRC de l'Île-d'Orléans. 47°01'12"; 70°50'16"O. Ruisseau du Moulin, secteur est de l'Île-d'Orléans, 800 m au nord de la route 368. Habitat : ruisseau. Présence de Salamandres à deux lignes.
17 juin 2002 : 2 adultes, obs. : D. Pouliot et N. Côté.

16. Mont-Sainte-Anne, MRC de la-Côte-de-Beaupré. 47°05'04"N; 70°54'01"O. Rivière Jean-Larose, 840 m au nord de la route 360. Habitat : eaux de résurgence. Présence de Salamandres à deux lignes.
15 août 2001 :1 adulte (récolté), JFD-01.10, obs. : D. Pouliot et I.-E. Gosselin. CMNAR 35718.
10 juin 2002 : 1 adulte (photographié), obs. : D. Pouliot, V. Tremblay et D. Banville.

17. Saint-Joachim, MRC de la-Côte-de-Beaupré. 47°04'13"N; 70°51'03"O. Ruisseau des Carrières, en bordure est de l'avenue Royale. Habitat : eaux de résurgence. Présence de Salamandres à deux lignes dans ruisseau à proximité.
4 juillet 2002 : 1 adulte, JFD-580, obs. : J.-F. Desroches et V. Tremblay. CMNAR 35719.

18. Cap-Tourmente, MRC de la-Côte-de-Beaupré. 47°04'55"N; 70°47'09"O. Ruisseau de la Friponne. Habitat : eaux de résurgence et ruisseau. Présence de Salamandres à deux lignes.
28 août 2002 : 2 adultes (1 récolté), JFDA-02.9, obs. : D. Pouliot, D. Banville et V. Tremblay. CMNAR 35721.

19. Cap-Tourmente, MRC de la-Côte-de-Beaupré. 47°04'59"N 70°46'42"O. Ruisseau Pierré. Habitat : ruisseau. Présence de Salamandres à deux lignes.
28 août 2002 : 2 adultes, obs. : D. Pouliot, D. Banville et V. Tremblay.

20. Cap-Tourmente, MRC de la-Côte-de-Beaupré. 47°05'05"N; 70°46'16"O. Ruisseau Pierré. Habitat : ruisseau. Présence de Salamandres à deux lignes.
28 août 2002 : 2 adultes (1 récolté), JFD-02.8, obs. : D. Pouliot, D. Banville et V. Tremblay. CMNAR 35720.

First Records of Long-beaked Common Dolphins, *Delphinus capensis*, in Canadian Waters

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Ford, John K. B. 2005. First Records of Long-beaked Common Dolphins, *Delphinus capensis*, in Canadian Waters. Canadian Field-Naturalist 119(1): 110-113.

The genus *Delphinus* has recently been determined to be comprised of two species, the Short-beaked Common Dolphin, *D. delphis*, and the Long-beaked Common Dolphin, *D. capensis*. *D. delphis* is regularly observed in eastern Canadian waters, but is known only from a single stranding in British Columbia. Two specimen records and a series of sightings of *D. capensis* in British Columbian waters during 1993-2003, detailed here, are the first for this species in Canada. *D. capensis* normally ranges only as far north as central California, and its abundance in those waters increases in association with warm-water oceanographic events. Although the species appears to be rare in British Columbia, future sightings during warm-water periods might be anticipated.

Key Words: Long-beaked Common Dolphin, *Delphinus capensis*, Short-beaked Common Dolphin, *Delphinus delphis*, stranding, entanglement, feeding.

Dolphins of the genus *Delphinus* have a wide but disjunct distribution in warm temperate to tropical waters worldwide from about 40-60°N to roughly 50°S (Jefferson et al. 1993). Considerable uncertainty about the taxonomic status of *Delphinus* species has long existed, especially in the eastern North Pacific (Banks and Brownell 1969; van Bree and Purves 1972; Heyning and Perrin 1994). Dall (1873) proposed a new species *Delphinus bairdii* Dall from coastal waters of California, which he considered distinct in rostral length and colouration from *Delphinus delphis* Linnaeus, previously known from the Atlantic Ocean. The validity of *D. bairdii* was challenged by some authors (e.g., True 1889; van Bree and Purves 1972) and supported by others (e.g., Miller 1936; Banks and Brownell 1969). Until this uncertainty was resolved recently, the names *D. bairdii*, *D. delphis bairdii*, and *D. delphis* were applied inconsistently to eastern North Pacific *Delphinus* (Guiguet 1954; Norris and Prescott 1961; Heyning and Perrin (1994) recently reviewed the taxonomic status of *Delphinus* and provided clear evidence for two distinct species in the northeastern Pacific, the Short-beaked Common Dolphin, *D. delphis* Linnaeus, and the Long-beaked Common Dolphin, *D. capensis* Gray. *D. capensis* is equivalent to the original long-beaked form described as *D. bairdii* Dall, but the latter name is now considered a junior synonym and is not used (Rice 1998). Short-beaked and Long-beaked Common Dolphins can be distinguished reliably by colouration pattern and the proportional length of the rostrum in adults (ratio of rostral length to zygomatic width in *D. delphis* is 1.21-1.47 and in *D. capensis* is 1.52-1.77; Heyning and Perrin 1994). The validity of these two species has been corroborated by genetic analyses (Rosel et al. 1994) and they are now widely accepted (Rice 1998; Carretta et al. 2002; Reeves et al. 2002).

Short-beaked and Long-beaked Common Dolphins have generally allopatric ranges in warm-temperate and tropical regions of the Pacific and Atlantic Oceans, though they are narrowly sympatric in some coastal waters (Heyning and Perrin 1994; Perrin 2002). *D. capensis* appears to prefer shallower and warmer water than *D. delphis*, and is most often found within 50 nm of shore. In the northeastern Pacific, *D. delphis* ranges along the coast and pelagically from South America to southern British Columbia, while *D. capensis* is found primarily in the Gulf of California and along the west coast of Baja California north to central California (approximately 36°N; Carretta et al. 2002, Perrin 2002).

The status of *Delphinus* in Canadian waters was reviewed by Gaskin (1992) before *D. capensis* was recognized as distinct from *D. delphis*. Common Dolphins are frequently seen during summer and fall on the banks offshore of Nova Scotia, and occasionally range as far north as coastal waters off Newfoundland (approximately 50°N; Gaskin 1992). The species in this region is *D. delphis*, as *D. capensis* has not been recorded north of 20°N in the western Atlantic (Perrin 2002). In western Canadian waters, the genus has until recently been represented only by a single individual found stranded on southern Vancouver Island in April 1953. This specimen, an adult male, was described by Guiguet (1954) as *D. bairdii*, but the animal was judged to be *D. delphis* by Heyning and Perrin (1994) based on colouration evident in a photograph in the 1954 article (W. Perrin, National Marine Fisheries Service, La Jolla, California, personal communication). To confirm this identification, the skull of

the specimen was measured and found to have a rostral length to zygomatic width ratio of 1.37, clearly within the range diagnostic of *D. delphis* (Heyning and Perrin 1994). (Royal British Columbia Museum, Victoria, British Columbia.; catalogue number 5792, examined 12 January 2004). The following thus describes the first records of Long-beaked Common Dolphins, *D. capensis*, in Canadian waters.

The earliest record of *D. capensis* in British Columbia is from 2 February 1993, when a male Common Dolphin stranded alive at Mayne Island and died shortly thereafter (Table 1). Post mortem examination at the provincial Animal Health Centre revealed the animal to be in poor condition, with extensive osteomyelitis of the caudal vertebrae and a heavy parasitic infection. The animal was recorded as *D. delphis*, but no skeletal material or measurements were collected (R. Lewis, Animal Health Centre, Abbotsford, British Columbia, personal communication) Archived photographs of the specimen were subsequently located and examined, which showed the colouration pattern distinctive of *D. capensis*.

The species is next recorded in a series of sightings in the late summer and fall of 2002. On 21 August 2002, a single individual was observed and photographed in Port McNeill, northeastern Vancouver Island, British Columbia. The animal appeared lethargic and in poor health. During the period of 18 September to 2 October 2002, a pair of *D. capensis* was sighted on several occasions in Vancouver harbour. One of these individuals, shown in Figure 1, was determined from dorsal fin markings to be the same animal as in the earlier Port McNeill sighting. Next, a group of four Common Dolphins was observed and video recorded on 1 November 2002 at Goose Bay, on the central coast of British Columbia north of Vancouver Island. Examination of the video recording showed the animals to be *D. capensis*.

The last set of records involves a pair of *D. capensis* photographed in Victoria harbour, southern Vancouver Island, on 19 September 2003. In one of these animals, the distal 5-8 cm portion of the rostrum was bent at an approximately 45° angle to the left. This distinctive individual had been sighted previously, together with another Long-beaked Common Dolphin (probably the same companion as in Victoria), on several occasions approximately 150 km to the south, in Puget Sound, Washington, during July-August 2003 (S. Norman, National Marine Fisheries Service, Seattle, Washington, personal communication). On 7 October 2003, a pair of dolphins, including the animal with the deformed rostrum, became entangled in a gillnet during a salmon test fishery in Alberni Inlet, on the west coast of Vancouver Island. The animal with the deformed rostrum was released alive from the net, but the other animal died and was collected and frozen for later examination. On 28 October 2003, the released dolphin was again sighted near the location of the 7 October entaglement.

TABLE 1. Records of *Delphinus capensis* in British Columbian waters. All species identifications were made from photographs or video recordings of the animals' distinctive colouration, except for the entangled animal collected on 7 October 2003, the identity of which was confirmed by cranial measurements..

Date	Location	Position	Type	Number	Comments
2 February 1993	Mayne Island	48°51'N, 123°18'W	Stranding	1	Stranded alive, died en route to rehab facility.
21 August 2002	Port McNeill	50°35'N, 127°05'W	Sighting	1	Animal appeared lethargic
18 September – 2 October 2002	Vancouver harbour	49°16'N, 123°8'W	Sighting	2	Series of sightings of apparently same pair; one individual same as 21 August 2002 sighting from dorsal fin markings
1 November 2002	Goose Bay	51°22'N, 127° 39'W	Sighting	4	Tight group of 4 individuals swimming actively in bay; observed for approx. 2 hours.
19 September 2003	Victoria harbour	48°25'N, 123° 23'W	Sighting	2	Same pair as 7 October 2003
7 October 2003	Alberni Inlet	49°16'N, 123°8'W	Entanglement	2	One died, one released
28 October 2003	Alberni Inlet	49°16'N, 123°8'W	Sighting	1	Same animal released on 7 October 2003

FIGURE 1. One of a pair of *Delphinus capensis* observed in Vancouver harbour, 19 September 2003, showing the distinctive colouration of the species (see Heyning and Perrin (1994) or Reeves et al. (2002) for comparative illustrations of *D. capensis* and *D. delphis*). Photo by Anne Carson.

Post mortem examination of the entangled animal showed that it had been in good health and had been feeding. It was a male, 187 cm long and 80 kg in weight. Tooth rake scars on its body were positively matched to scars in photographs taken on 19 September 2003 of the animal accompanying the dolphin with the deformed rostrum. Its stomach contained remains of four Pacific hake (*Merluccius productus*) and six Pacific herring (*Clupea pallasi*). The skeleton of the dolphin was prepared and is now part of the collection of the Natural History Museum, Malaspina University-College, Nanaimo, British Columbia (catalogue number M-0283). The ratio of rostral length to zygomatic width is 1.69, well within the range measured for *D. capensis* (1.52-1.77; Heyning and Perrin 1994).

These recent records confirm that *D. capensis* occurs in British Columbian waters, but it is unlikely more than a rare visitor. The records presented here are the northern-most for the species in the eastern North Pacific. Previously, there had been no sighting or stranding records for *D. capensis* north of central California, though the species has only recently been differentiated from *D. delphis* in sighting surveys (Heyning and Perrin 1994; Carretta et al. 2002). *D. delphis* is common in both inshore and offshore waters off California, but no confirmed sightings have been made in waters off Oregon and Washington (Carretta et al. 2002). Of four stranding records of Common Dolphins on the coasts of Oregon and Washington, only one, a *D. delphis*, was identified to species (Carretta et al. 2002). There are no confirmed records of *D. delphis* in British Columbia since the 1953 stranding. In Californian waters, the abundance of the two species varies both seasonally and inter-annually, with highest densities associated with warm-water events (Heyning and Perrin 1994, Forney and Barlow 1998). Heyning and Perrin (1994) noted that the proportion of *D. capensis* versus *D. delphis* strandings on the coast of California increased for several years following the warm-water El Niño of 1982-83. The appearance of *D. capensis* in British Columbian waters may be associated with increased water temperatures, and future sightings might be anticipated during warm-water periods.

Acknowledgments

I thank the following for their assistance: W. Perrin, J. Heyning and R. Pitman for confirming species identification from photographs; G. Ellis, L. Barrett-Lennard, and M. McDonald for information on sightings; R. Lewis, A. Carson and E. Westle for providing photographs; M. O and L. Spaven for collecting the entangled specimen, J. Watson for facilitating its post mortem examination, and S. Raverty for undertaking the necropsy; S. Crockford for identification of stomach contents; L. Kennes for providing access to the skull of the 1953 specimen at the Royal British Columbia Museum; S. Norman for information on *Delphinus* sightings in Washington state; and D. Nagorsen for helpful comments on an earlier draft of the manuscript.

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Received 3 August 2004
Accepted 7 March 2005

Occurrence, Composition and Formation of *Ruppia,* Widgeon Grass, balls in Saskatchewan Lakes

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Olson, Randy W., Josef K. Schmutz, and U. Theodore Hammer. 2005. Occurrence, composition and formation of *Ruppia,* Widgeon Grass, balls in Saskatchewan Lakes. Canadian Field-Naturalist 119(1): 114-117.

Widgeon Grass *(Ruppia maritima)* is an aquatic vascular plant (Ruppiaceae) which has been the source for rare balls of plant material found at the shores of lakes on four continents. In North America, the lakes involved were in North Dakota, Oregon, and now northern and southern Saskatchewan. The formation of the balls has not been observed in nature, but similar balls have been produced in other studies with *Posidonia* or Turtle Grass (Hydrocharitaceae) fibers under the wavelike action in a washing machine. Our samples are from a saline lake in southern Saskatchewan (49°N), and an over 40-year-old sample from an unknown lake north of the boreal transition zone (52°N). Comparisons of the plant material with herbarium specimens confirm that the balls are almost entirely comprised of *Ruppia maritima,* with minor items including invertebrate animal parts, sand pebbles and feathers. The context in which the material was found is consistent with the proposition that they are formed by *Ruppia* inflorescences breaking apart, drifting to near shore due to wind and being rolled into balls by wave action.

Key Words: *Ruppia maritima,* Widgeon Grass, plant balls, saline lake, Saskatchewan.

Unusual balls of plant material were encountered at shores of two different lakes in northern and southern Saskatchewan. Judging from available literature, similar balls have been found in Europe, North America and New Zealand (Cannon 1979; Essig 1948; Gerbeaux and Ward 1986). While the actual formation of these balls has not been observed in nature, the combined action of waves on fragments of aquatic vegetation near shores is thought to be involved. Such balls have, however, been produced using *Posidonia* or Turtle Grass (Hydrocharitaceae) fibers under the wave-like actions simulated by a washing machine (Cannon 1979).

Names for the plant balls exist in Dutch, English, French, German and Italian, 15 names in total (McAtee 1925). Some of these names date back to classical times (E. A. Parry *in* Cannon 1979). This attests to a widespread, even if rare, occurrence of these balls. The names also attest to a degree of fascination; a curiosity likely enhanced by the unpredictable occurrence of these structures in nature.

Sample Sources

Our collection includes six balls of plant material in two sets. One set was located at Sandoff Lake (49°00'N, 104°18'W) in the Lake Alma Upland within the Missouri Coteau of south-central Saskatchewan. Sandoff Lake is a 1 km^2 saline lake in a hill-and-dale landscape. Sandoff Lake has no above-ground outflow, and lies in the Missouri-Mississippi River drainage (Fung et al. 1999). As is typical of many saline lakes, it is probably fed through ground water in addition to runoff and springs visible on the lake's shore. Sandoff Lake goes dry in some or most years. On 20 October 2000 there was no standing water covering the white salt flat.

A second set of plant balls was found during lake studies in the 1950s by D. S. Rawson (e.g., Rawson and Moore 1944). The balls were given to UTH about 1960, but data on time and location of collection were not recorded. The collection has been given to Glenn Sutter, for inclusion in the natural history collections of the Royal Saskatchewan Museum in Regina (RSM Accession 17443).

Results and Discussion

More than 50 plant balls were first found on 6 July 2001 by JKS along the southeastern shore of Sandoff Lake (Figure 1) where the prevailing winds are northwesterly. The balls were scattered in a band approximately 3 m wide and 100 m long, at the high water mark where the pebbly shore merges with short-grass prairie. The balls were still present, although more encrusted in salt, on 30 June 2003. Their position in a single layer, similarity in salt or algal coverage and slightly compressed form suggests that only one generation of such balls occurred during the three years. Their position at the upper reaches of the shore suggests that the balls may have been washed there during strong winds but not returned to the lake with the receding water during calmer weather. A walk around the lake revealed two sets of balls on the east but none on the west (primarily upwind) shore.

Analysis of the material in the two sets of balls showed that they were composed mainly (greater than 95%) of *Ruppia* inflorescence stems, peduncles, and

fruits. The fruits were black, ca. 2 mm long, and beaked. These identifications were based on comparisons between the samples and specimens from the W. P. Fraser Herbarium, and descriptions from several floras (e.g., Haynes 2000). In three of the balls from Sandoff Lake, *Ruppia maritima* L. was identifiable. Small amounts of other material found included twigs, small pebbles, and a feather.

Saskatchewan has two species of *Ruppia*: *R. cirrhosa* (Petagna) Grande (synonym = *R. occidentalis* S. Wat.) and *R. maritima* L. (Harms 2003). *Ruppia maritima* is found in the southern third of Saskatchewan, and *Ruppia cirrhosa* is found in the southern half of the province (Hammer and Heseltine 1988; W. P. Fraser Herbarium). In North America, *Ruppia maritima* is found throughout eastern and western coastal regions (Haynes 2000). *Ruppia cirrhosa* is found from Alaska south to Texas and From California east to the Great Lakes (Haynes 2000).

The two species of *Ruppia* belong to Ruppiaceae, the Ditch-grass family, also known as Widgeon Grass (Haynes 2000), The one genus includes approximately 10 species worldwide, and two in North America. *Ruppia* is an annual, or rarely perennial, sessile herb submersed in brackish or saline water. Flowering occurs spring-fall.

The plant balls as shown by Essig (1948), and Swanson and Springer (1972) are highly similar to our material. Also, *R. maritima* L. seems to be the primary plant species involved, at least in North America (Table 1). This suggests that the conditions that favour ball formation are relatively specific. The involvement of saline

FIGURE 1. *Ruppia maritima* balls located at the southwest shore of Sandoff Lake in Saskatchewan, on 6 July 2001.

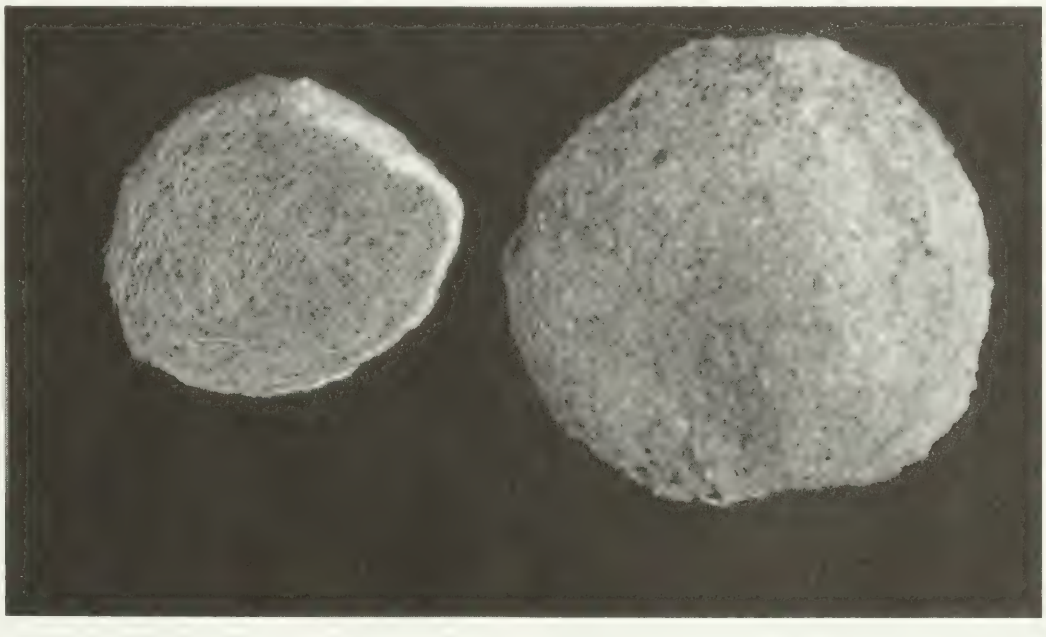

FIGURE 2. Two *Ruppia maritima* balls. One (left, 6.0 cm diametre) from Sandoff Lake, and the larger (right, 13.5 cm) from northern Saskatchewan.

TABLE 1. Characteristics of plant balls as reported in the literature and found in our Saskatchewan samples.

Site Name	Location	Lake Type	Plant Species	Reference
No name	NE North Dakota	Saline	*Ruppia maritima*	SS 1972
Mediteranean	–	Sea shore	*Posidonia oceanica*	JFMC 1979
No name	Near Dawson, ND	Saline	*Ruppia maritima*	FPM
Miller Lake	Oregon	–	"similar" to FPM	GWF
Little Borax Lake	California	Saline	*Ruppia maritima*	EOE 1948
Sandoff Lake	S Saskatchewan	Saline	*Ruppia maritima*	This report
Unknown	N Saskatchewan	Unknown	*Ruppia maritima*	This report

References: SS = Swanson and Springer 1972, JFMC = Cannon 1979, FPM = F.P. Metcalf *in* McAtee 1925, GWF = G. W. Field *in* McAtee 1925, EOE = E.O. Essig 1948.

lakes may not be crucial to ball formation but merely reflect that *Ruppia* is a saltwater species. The stems of *Ruppia* are delicate, relying on the surrounding water to support their mass (Kantrud 1991*). The stems are likely susceptible to breakage during periods of unusual turbulence. The stem bases also decay as the plants reach senescence (Kantrud 1991*). These two factors would leave large amounts of plant material in the water in late summer and/or fall, likely leading to the homogeneous content of the *Ruppia* balls.

Given the structure of the balls, the location in which they were found and explanations from the literature, we suggest that the following mechanisms are involved in their formation. The fibrous stalks of *Ruppia* are prone to breakage and to sticking together. Two balls that were cut (Figure 2) and one that was teased apart suggest that the material is *Ruppia* throughout and does not contain any other material in its core. When the stems of the *Ruppia* break and tangle together, floating mats accumulate and are driven by wind to the shore (e.g., Essig 1948). Here, the repeated wave action in combination with the resistance provided by the shore in shallow water rolls the mat back and forth. This rolling action was thought responsible for producing balls of plant material in the lint trap of a washing machine (Cannon 1979). Finally, on windy days the balls may be washed up onto shore out of reach of the lapping waves on calm days that might otherwise return the balls to water where they may decay. The distribution of balls at Borax Lake (Essig 1948) suggests that the balls were deposited over time as water evaporated and the shallow lake receded, differing slightly from our accumulation at the shore. Judging from the misaligned fibers in our material, interconnected in seemingly all directions (Figure 2), we doubt that the balls have grown in layers (e.g., Essig 1948). Instead, the different sized balls may simply be due to different amounts of plant material in a mat that starts to roll on the shore. In the Sandoff Lake sample, salt spray had encrusted the balls and, combined with grass shoots growing through the balls, had firmly anchored the balls on the upper shore. The Sandoff Lake balls tended to be oval. We suggest that they were round originally but that the material settled to an oval shape after they were covered in salt, dried and became anchored on the shore.

The formation of balls by wave/wind action and friction is not limited to aquatic plants. Near Blaine Lake, Saskatchewan, wind combined with large and wet snowflakes led to snowball formation observed on the packed snow in a yard (Julie Hupé, personal communication). Pierce et al. (2004) compared amorphous, decomposed remains of large animals that washed up on a Chilean shore in 2003 (Chilean Blob), with other such "carcasses" variously reported as sea monsters for over a century. Such sightings occurred in Bermuda (n = 2), West Coast of Tasmania, and Northeast Coast of the United States in addition to Chile. The authors identified the material as decomposed remains of large whales. The material was held together by cross-hatched layers of collagen fibers. This flexible layering of collagen in a blob was different from the firm arrangement of the inflorescence stems in our *Ruppia* balls.

Acknowledgments

Dennis Dyck kindly took the photo of the balls and Blaine Novakowski sliced them for analysis. Glenn Sutter cataloged the material as part of the Royal Saskatchewan Museum's collections (RSM Accession 17443).

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Received 23 April 2004
Accepted 11 February 2005

Why and How to Study a Snowcover

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Pruitt, William O., Jr. 2005. Why and how to study a snowcover. Canadian Field-Naturalist 119(1): 118-128.

Specialized terminology, duration, thickness, hardness, density of the snowcover of taiga and tundra are described. Methods for detailed study of these characteristics are given, with description and use of simple as well as specialized instruments and techniques in relation to winter ecology of mammals and birds.

Key Words: snow, snowcover, taiga, tundra, snow ecology, winter ecology, boreal ecology, snow instruments, snow terminology.

Why is it necessary to study and record the details of a snowcover? Is not knowledge of the thickness of the cover (or even just its presence or absence) sufficient to explain the use or lack of use of an area by animals? In this paper I will show how details of a snowcover affect not only the presence or absence of a species but also how a species can use the snowcover, how it is affected by the variations in the snowcover morphology or sometimes is induced to emigrate from a region because of characteristics of only one layer in the snowcover

Moreover, some species move down from the surface of the snowcover or up into the snowcover itself for varying periods of time. For some species the snowcover acts as a hindrance to travel or to obtaining food from under it, to others as a blanket protecting life from the deep cold of Full Winter (Pruitt 1957, 1960). This paper will also describe and review widely-accepted, as well as specialized, descriptors, instruments and measuring techniques. These techniques give one the tools for basic descriptive analyses of snow features. Sturm (1992) demonstrated, based on such a framework, an analysis of heat flow through taiga api as affected by qali fall and bare qamaniq.

Terminology

The English language evolved in a misty, maritime climate where snow was an uncommon occurrence, consequently it is woefully deficient in words representing snow phenomena. The "scientific" languages (Latin and Greek) are derived from cultures which had even less familiarity with snow and its various forms than did English. Therefore, it seems best to use precise words that designate features and concepts from cultures that have evolved closer ecological links with snow than our Euro-Canadian one. Familiarity with these words exposes us to a whole new world of snow. The participants in the Scandinavian-Canadian Field Workshop on *Rangifer*-Snow Ecology (Pruitt 1971) resolved "...to assemble all known snow terms in all northern languages and to illustrate each term with a photograph or accurate drawing. We believe that publication of such a lexicon would materially advance the study of boreal ecology. We invite submission of snow terms and photographs for possible inclusion in the lexicon." Table 1 consists of some words from such cultures that my students and I have found especially useful in our studies of snow ecology (Pruitt 1978, 1979, 1999). The simplified spelling and pronunciation of these words is given, enclosed in brackets, immediately after the first use in this paper.

There are four major qualities of a snowcover, particularly as they affect living organisms: Duration, Thickness, Hardness, and Density (Pruitt 1984a). The latter two characteristics enter into calculations of "snow water equivalent" and are influenced primarily by wind and the occurrence of winter thaws or freeze-thaw cycles. Thus there are four combinations that generally agree with four major geographic types of snowcover:

- steppes and coastal regions with freeze-thaw and wind,
- tundra with wind and no freeze-thaw,
- inland southern regions with freeze-thaw but no wind,
- taiga with no freeze-thaw and no wind.

This classification has recently been confirmed in general by Sturm et al (1995). Confusion sometimes still exists between "arctic" and "taiga" snow processes, especially concerning the known effects of snowcover on large mammals such as wolves, foxes and caribou (Olsson et al. 2003).

Duration

The onset and disappearance of a snowcover, whether taiga api [ah-PEE] or tundra upsik [OOP-sik] (Table 1), are accompanied almost always by fluctuations in snowcover over the landscape. Inexperienced researchers have a tendency to fail to record the details of exact position and shape of the transitory spots where api first forms and where it lingers longest. One should make an effort to record these characteristics, preferably by detailed sketches including measurements of the spots and their exact locations, as well as times they occur. These spots and connecting areas will probably be where the Hiemal Threshold (Pruitt 1957) will occur first. The sequence of Fall Thermal Overturn, Fall Critical Period, Hiemal Threshold, Full Winter, Hiemal Termination, Spring Critical Period, Spring Thermal Over-

turn (Pruitt 1978, Figure 4-1; 1984b) are all important events in the cycle of the seasons for the plants and animals of the forest floor. The duration and intensity of the fall and spring critical periods can govern survival of populations of small mammals (Whitney and Feist 1984). For some individuals or age-classes of a population of Caribou (*Rangifer tarandus*), overwinter survival seems to be a race between decreasing body mass ("loss of condition") and duration of the snowcover.

One of the important environmental factors affecting snow is wind. If wind is lacking, the complex, six-armed snow crystals drift down and settle undisturbed on other crystals which have preceded them, or onto the ground and short vegetation. Here, over time, they will undergo metamorphosis driven by the heat and moisture rising from the earth below (Schemenauer et al. 1981; Seligman 1936). This heat and moisture will modify the snow crystals by subliming water molecules from the attenuated tips of the arms and redepositing them on colder crystals farther from the earth. The bottom-most crystals are the oldest and, therefore, have undergone this process the longest. Consequently, they are the most modified. Sometimes they are completely eroded away and their molecules have been redeposited higher up in the snow cover. Because of the physics of snow crystals the modified ones are in the shape of six-sided scrolls or pyramids.

They can reach 10 mm or more in size and, upon magnification, they look as if they are made from tiny glass logs (Figure 1). The metamorphosed layer can extend 10 cm or more up into the cover and is properly known as pukak [POO-kak]. This layer is of great importance to subnivean mammals and winter-active invertebrates. In some subalpine or northern taiga regions where there is intense heat-loss from the snowcover surface, almost all the snowcover can consist of pukak.

Such is the idealized situation, with the api affected only by the heat and moisture rising from the earth, and with little or no heat coming from the supranivean air. In temperate and maritime climates where warm, moist air masses can intrude on the winter climate there can be heat and moisture gradients moving downwards as well. In these conditions pukak may not form, or may be severely modified (Pruitt 1984b). On the island of Newfoundland, with its relatively warm, wet, yet snowy, maritime climate, I found pukak in only a few sites near the upper limit of trees in the Long Range Mountains. I suspect that the general lack of pukak is as reasonable an explanation for the island's markedly depauperate small mammal fauna as is any species' inability to cross the Strait of Belle Isle (Pruitt 1968). Indeed, I now believe that pukak, not only its physical condition as a safe winter habitat for small mammals and invertebrate life, but as an indicator of general winter conditions for all boreal life deserves a great deal more research attention than it has had in the past.

TABLE 1. Specialized snow terminology of some northern peoples. Transliterations in parentheses after aboriginal word indicate pronunciations in general English sounds. (Capitalized syllable means stress accent; "q" indicates a hard, glottal stop)

English	**Kobuk Valley (Alaska) Inupiat**
Snow	anniu (ah-NEE-u)
Snow on trees	qali (KAH-lee)
Dense crystals, moist air hitting very cold surface	kanik (KAH-nik)
Snow on the ground,soft fluffy taiga snow	api (ah-PEE)
Base of snowcover, with large, pyramidal crystals	pukak (POO-kak)
Hard, wind-beaten snow (tundra or prairie)	upsik (OOP-sik)
Drifting snow	siqoq (see-KOK)
Smooth snow surface of very fine particles	salumaroaq (sah-loo-MAH-roak)
Rough snow surface of large particles	natatgonaq (nah-tat-GO-nak)
Sun crust	siqoqtoaq (see-KOK-toe-ak)
Drift downwind of an obstruction	kimoaqruk (kee-mo-AK-rook)
Space between drift and obstruction causing it	anyemanya (ahn-ye-MAHN-ya)
Arrowhead-shaped drift moving over upsik	kalutoganik (kah-lu-toe-GAHN-ik)
Wind-eroded upsik from kalutoganik	kaioglaq (kai-OHG-lak)
Irregular surface caused by differential erosion	tumarinyiq (too-mar-IN-yik)
Bowl-shaped depression in api around base of tree	qamaniq (KAH-mahn-ik)
	Dindye (Fort Yukon, Alaska)
Snowcover thick enough to need snowshoes	detthlo(k) (DET-thlo(k))
	Russian
Spot blown bare of snow	vyduvi (vih-DOO-vi)
Area of thick snow cover, persists all summer	zaboi (ZAA-boy)
	Finnish
Animal's overnight burrow in the snow cover	kieppi (KEY-eppi)
Kanik crystals, vertical surface	Huurre (HOO-rreh)
Kanik crystals, horizontal surface	Kurra (KU-rra)

In spring, especially in alpine regions and in the High Arctic, the long hours of intense solar radiation can melt or sublime the snowcover surface and meltwater can trickle down through the upsik and refreeze against the ground (Miller and Kiliaan 1980). This phenomenon is known to Sami reindeer herders as čuokki [CHU-ok-ki] (Eriksson 1976; Pruitt 1979). Miller and Kiliaan (1980) outlined the severe effects of Canadian High Arctic čuokki on large mammals such as Peary Caribou *(Rangifer tarandus pearyi).*

Thickness

Thickness is governed by latitude, proximity and direction from major sources of atmospheric moisture, as well as the regional climate. Thickness, especially in mountainous regions, can affect supranivean animals simply by hiding or "smoothing over" portions of the overwintering habitat. In steep, rocky or irregular terrain this can result in falls causing broken limbs. Murie (1935) noted the importance of snowcover in the migrations and seasonal distribution of Alaska Caribou, most of which are essentially mountain animals. Edwards and Ritcey (1959) discussed the effects of snowcover thickness on the altitudinal migrations of Moose *(Alces alces)* in British Columbia and Edwards (1956) correlated snowcover thickness and trends in ungulate populations. One of the classic publications in snow ecology is Nasimovich (1955) who demonstrated the influence of snowcover thickness on wintering aggregations of Moose in the Ural Mountains.

Mammals as large as Fisher *(Martes pennanti)* occasionally burrow into the api in a kieppi [KEY-eppi], as a hunting tactic or to escape extreme cold. Tundra mammals such as Arctic Fox *(Alopex lagopus),* Red Fox (*Vulpes vulpes)* or even Wolverine *(Gulo gulo)* will seek shelter by burrowing into soft spots in upsik or inside the curl-space of a snow cornice or a drift (Pruitt, unpublished observations.).

Grouse-like birds frequently use kieppi to escape low temperatures and predators (Formozov 1970; Korhonen 1980a, 1980b; Marjakangas 1986). The latter worker noted that four major factors have to be considered when defining the influence of api conditions on construction of kieppi: (1) the presence of crusts within the api, (2) the penetrability of these crusts, (3) the thickness of any soft snow on top of the crust, and (4) the total api thickness. Penetrability mainly depends on hardness and thickness of the crust. Crusts of up to 2000 to 3000 gm cm^{-2} (20 to 30 N) vertical hardness are "readily penetrable," whereas harder crusts are difficult to penetrate. Therefore the minimum requirements of api conditions for use of kieppi by Black Grouse *(Tetrao tetrix)* in Finland are:

- When a crust which is difficult to penetrate is covered by less than 10 cm soft api, then Black Grouse *(Tetrao tetrix)* in Finland roost in trees and on the api surface, but not in kieppi. The total thickness of the api is not important.
- When there is at least 4 cm of soft api over a readily penetrable crust (provided that the overall thickness is at least 10 cm) then Black Grouse begin to roost in kieppi as well as in trees and on the api surface.
- They roost only in kieppi when the readily-penetrable crust is covered by a layer of soft snow at least 10 cm thick and the total thickness of the api is about 27 cm.
- Marjakangas (1986) concluded that Black Grouse roost in open burrows on the api surface as well as in trees when the total thickness of the api is from 10 to 26 cm and exclusively in kieppi when the thickness is 27 cm or more.

In his exhaustive study of the winter ecology of Capercaillie *(Tetrao parviventris)* and Black Grouse in Finland, Seiskari (1962) put the use of kieppi into context of habitat type, food supply and weather. The temperature within Willow Grouse *(Lagopus lagopus)* kieppi rose to at least -6° even though ambient temperature fell to -35°; relative humidity was always saturated and CO_2 density was never elevated above ambient (Korhonen 1980a). Andreev and Krechmar (1976) found kieppi temperatures of -10° and -11° with ambient temperatures of -45°. Volkov (1968) had found similar conditions with Hazel Grouse *(Bonasia bonasia)* and Black Grouse (*Tetrao tetrix).*

Other, smaller, birds may use kieppi also: Yellowhammer *(Emberiza citrinella)* (Järvi and Marjakangas 1985), Common Redpoll (*Carduelis flammea)* and Greyheaded Tit *(Poecile cinctus)* (Korhonen 1980b), Snow Bunting (*Plectrophanax nivalis)* (Thiede 1982), Song Sparrow (*Melospiza melodia)* (McNicholl 1980), Marsh Tits (*Poecile palustris),*Willow Tits (*P. montanus),* Great Tits (*P. major),* Long-tailed Tits (*Aegithalus caudata),* Snow Bunting (*Plectrophanax nivalis),* Bullfinch *(Pyrrhula pyrrhula),* Common Redpoll *(Carduelis flammea)* (Novikov 1972) and others (Sulkava 1969; 1989). Cade (1953) reported *Carduelis flammea* burrowing into api not only for thermal protection but to find seeds under the surface of the api.

In periods of extreme low temperatures some birds such as the Redpolls (*Carduelis flammea* and *C. hornemanni)* continue to feed in the coldest air zone, (on the api surface), by contracting their feet and legs within the feather coat and, using their wing primaries and tail feathers, support and "roll" themselves over the api surface (Johnson 1954).

Instruments and techniques associated with thickness will be found later under the section entitled "General Procedures."

Qali

Taiga snow occurs in two phases: api [ah-PEE] or snow on the ground and qali [KAH-lee] or the snow on the trees (Pruitt 1958). In temperate regions qali is of only transitory aesthetic importance or when determining total water content. In the taiga, however, qali is a long-lasting and significant ecological factor. It has been an influence in the evolution of the shape of spruce trees; it is a powerful influence over vegetation type because it governs some aspects of forest succession (Gill et al 1973; Pruitt 1958) and it can affect human-made structures such as powerlines by breaking them.

FIGURE 1. Closeup photo of subnivean space and pukak crystals. Ruler ticks are 1 mm apart. Manitoba, Agassiz Provincial Forest, 4 March 1978. Photo by Wolf Heck.

Qali can be quantified by means of "qalimeters," but the study of qali is in its infancy at present and the standardization of observations would be premature (Pruitt 1973). Research continues at Taiga Biological Station on characteristics and suitability of different types of qalimeters.

Qali forms best under conditions of frequent, light snowfalls, reduced incoming solar radiation and no wind. A superficially-confusing phenomenon called kanik [KAH-nik] forms when relatively warm, moisture-laden air strikes cold objects (Pruitt 1984a, Figure 5). It forms best under conditions near freezing, with light winds. Qali forms in varying amounts on horizontal surfaces, while kanik forms a layer of more-or-less uniform thickness, or sometimes spikes or needles, usually on vertical surfaces (Miller 1962, 1964, 1966). To complicate things, kanik sometimes forms on previously-deposited qali or even on the api or upsik surface. Kanik that forms on vertical surfaces is known in Finnish as huurre [HOO-rre]; on horizontal surfaces it is known as kurra [KU-rra[(Sirpa Rasmus, personal communication).

Qali affects animals such as birds and arboreal mammals by interfering with their feeding and travel. During periods of heavy qali accumulation birds such as Pine Grosbeaks *(Pinicola enucleator)*, Chickadees *(Poecile spp.)* and Red Crossbills *(Loxia curvirostra)* forage on windy hilltops, where qali is blown off the trees. Pine Marten *(Martes martes)* and the Red Squirrel *(Sciurus vulgaris)* in Eurasia (Pulliainen 1973) and the North American Red Squirrel *(Tamiasciurus hudsonicus)* find their arboreal activities affected by heavy qali accumulation (Pruitt, unpublished data). On the other hand, some small birds such as Tits and Chickadees protect themselves from excessive radiant heat loss by huddling under lumps of qali (Steen 1958). Showshoe Hares *(Lepus americanus)* use snow caves formed under qali-bent shrubs; thus their body radiant heat will not be lost to the infinite heat sink of the night sky (Pruitt 1984a). In contrast, qali bends shrubs over, so that their tender growing tips are brought within reach of the hares. This presents the hares with a supplementary source of food (Bider 1961).

Hardness

The snowcover that accumulates under windless conditions will be made up of flakes supported by their arms and touching each other only on the tips. Consequently most of the mass is air with relatively little ice in it. In the taiga or northern coniferous forest the snow season is characterized by little wind, a marked reduction of incoming solar energy and few incursions of mild maritime or tropical air masses. The result is a snowcover that arrives early in the autumn and lasts all winter, relatively unaffected by thaws or wind.

Hardness (H) is an expression of the force required to collapse the structure of the api. Most measurements of this force have been presented in detailed snow ecology publications as gm cm^{-2}. In the remainder of this paper such units will be followed by *Système Internationale (SI)* units such as Kg m^{-2} or Newtons [N; 5Kg = 50N] set off by brackets.

Hardness of taiga api can be from ~<2 to ~50 gm cm^{-2} [0.02 to 0.5N]. If the flakes are windblown they will be jumbled about, their fragile arms broken off and stripped and, when they come to rest, they will lie snugly against each other. Here they will also undergo metamorphosis. A snowcover of jumbled, wind-tossed and broken flakes will contain more ice. The density will still be only about 0.30 [300 kg m^{-3}], however. Such a snowcover is properly termed upsik [OOP-sik]. Hardness of upsik can get as high as 99 000 gm cm^{-2}. [990 N]. Hardness is of considerable importance to supranivean animals as large as Caribou because it can impede their movement as well as their access to subnivean vegetation (Fancy and White 1985) except under very special conditions (Pruitt 1979)

The upper part of the snowcover in a tundra or cold steppe region consists of two phases: the consolidated mass (upsik) and above it the moving snow, called siqoq [see-KOK], propelled by the wind. Siqoq periodically becomes consolidated into a sequence of drifttypes (Pruitt 1966, 1984a, 1999). The several types form and are eroded away as they reform and move over the surface of the upsik. The drift succession is known reasonably well (Pruitt 1970) but any effects of the drifts on animals (especially subnivean animals) are poorly understood. The best-known effect is that of anyemanya [ahn-ye-MAN-ya] around obstructions to the flow of air (Pruitt 1984a). Sulkava (1964) has shown that anyemanya are important in the ecology of Grey Partridge *(Perdix perdix)* and European Hare *(Lepus europaeus)* on the Ostrobothnian Plain of western Finland. Pulliainen and Iivanainen (1981) showed how distribution of snowcover, especially anyemanya, affected the winter diets and grit-gathering of Willow Grouse *(Lagopus lagopus)* in far northern Finland. Anyemanya are well-known in the folk knowledge of northern peoples as places where animals congregate on the exposed vegetation or soil to obtain food or grit for gizzards. Such places are good sites for traps or snares. I have followed Arctic Fox *(Alopex lagopus)* as they zig-zagged across the tundra landscape, investigating one boulder-centred anyemanya after another; there is always the possibility of surprising a ptarmigan gravelling there.

Upsik occurs in two facies which have biological importance (Pruitt 1984b). Convex ground surfaces, blown clear of snow winter after winter, are called vyduvi [vih-DOO-vih] and are subject to extreme cryopedological processes. Concave ground surfaces collect snow each winter, are called zaboi [ZAH-boy] (Table 1), and are protected from temperature extremes.

Zaboi can be regulators of mesic habitats in an expanse of otherwise rather xeric conditions. Zaboi collect siqoq from over a wide area and concentrate it (as well as any contaminants attached to the siqoq particles). As the zaboi slowly melt during the summer, the meltwaters and the contained contaminants, such as radioactive particles from fallout, collect downhill of the zaboi (Osburn 1963). The meltwater nourishes wet sedge mats which absorb large quantities of it. Any contaminants, radioactive or otherwise, are immobilized by the sedges. The sedge mats are not perfect sinks, however. Eventually the sinks will "fill up" and the contaminants will flow through and enter the meltwater system. This situation deserves attention and further research because virtually every city in western and central North America gets its water supply, originally, from zaboi (Osburn 1963).

Small taiga mammals such as the voles *Clethrionomys* spp.or *Microtus* spp.or shrews *Sorex* spp., when unable to escape from the api surface during cold periods, can survive such conditions only a few hours. Undisturbed taiga api can have a vertical hardness range of <3 to 50 gm cm^{-2} [0.02 to 0.5N]. A trail made by a dozen passes of humans on skis can have a vertical hardness range of 25 to 7 500 gm cm^{-2} [0.25 to 75N], but a trail made by only two passes with one person on a snowmobile can have vertical hardnesses of 550 to 7 000 gm cm^{-2} [5.5 to 70N]. Moreover, a snowmobile, because of its weight and the churning action of the track, destroys the pukak layer and makes the api the same hardness throughout its total thickness (Pruitt, unpublished data). In effect, snowmobiles change api into upsik. Small mammals, when tunnelling through the layers of this highly modifed snow cover, can tumble into such trails and be unable to excavate a re-entry hole into the api.

It is clear from this discussion that it is not only the thickness or hardness of the api that can be critical but also the location of the hard layer in the snowcover.

Hardness Measurements

I have found that a kit of snow instruments should have three hardness gauges: a high-range one, with a red stripe around it (calibrated from 0 to 100), a medium-range one (calibrated from 0 to 10) and a very-low-range one (calibrated from 0 to 2). There should be, as well, four separate discs. The discs are snapped onto the push-rod with their smooth faces outward. The largest disc results in the reading on the calibrated end of the push-rod to be multiplied by one, the next smaller disc reading is to be multiplied by 10, the next smaller disc is to be multiplied by 100. The smallest disc is the cylindrical end of the push-rod itself and its reading should be multiplied by 1 000. In the snow kit there should also be an elongated narrow bar or strip that has the same effective area as the largest disc. Use of this bar enables one to sample relatively thin layers in the api, thus making the results more precise. One can dif-

ferentiate hardnesses of, for example, six layers in a given profile instead of only four layers with the circular discs alone.

Start measuring hardness by using the medium range gauge and attaching to it the largest disc that will fit the topmost layer of the api exposed on the vertical cut face. Push the gauge and disc, horizontally, slowly and steadily against the cut face. Be sure to engage the disc and the cut face with a horizontal motion otherwise error will be produced (e.g. Brown and Theberge 1990). At first, there will be a bit of surface crumbling. Continue pushing until the crystalline structure suddenly collapses. The ratchet on the push-rod keeps the calibrations in view so that the maximum force needed can be read and recorded.

Repeat the procedure several times, each in an adjacent, fresh spot of the layer. Continue the procedure for each layer of the api. Undoubtedly you will have to use several combinations of gauges and discs to get combinations that will fit each layer and its hardness. Considerable practice is necessary in order to achieve consistently-reproducible results.

A characteristic of the snowcover which I have found useful when considering supranivean animals is vertical hardness (VH). Use the proper combination of gauges and discs and bring them vertically down onto the surface until the crystal structure of the surface layer collapses. Horizontally cannot be substituted for vertically in this measurement (Pruitt 1990). A useful variant of VH is vertical hardness to track depth (VHT). Choose a disc approximating the animal track in area and push it vertically down to the same depth below the surface of the snowcover that the track reaches. The Swiss "ramsonde," because of its total mass, cannot be used on soft taiga api.

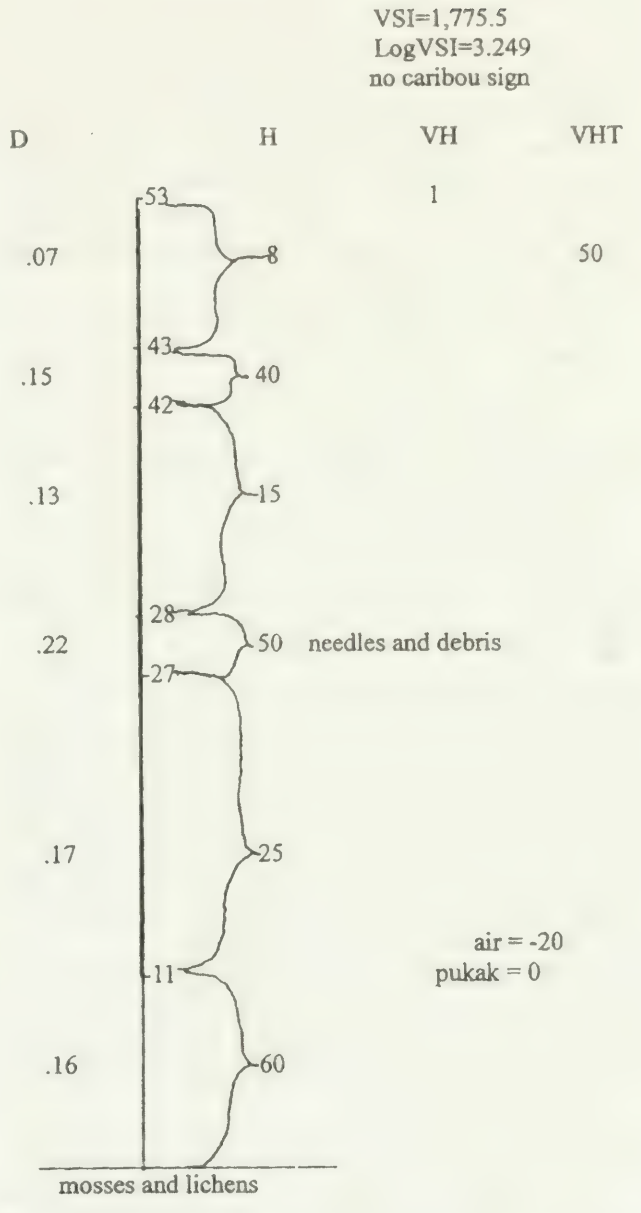

FIGURE 2. Sample data form and typical data from an api station. Station 80. 1958-02-26 Saskatchewan. 56°34'N 108°16'W. 10m from North Shore, Lake. Mature white spruce-birch. Qali breaks.

Density

Density is a function of the complex history of a snowcover, from the aerial formation of the original crystals, the amount of fracturing and any possible thawing events they have undergone. The more complex the history, the denser the snowcover probably is.

Density is relatively easy to measure, even using simple "kitchen hardware." The weight of a given volume of snow is divided by that volume. The expression (D) is a ratio, expressed without units, of the amount of ice in relation to the total enclosed volume. Density of the api has three main effects on living things:

- It expresses the water content of the snowcover, which can influence the magnitude (and therefore the quality) of spring runoff. Increases in density, for example, dramatically increase the water content.
- Density can be important to the survival of subnivean organisms because it governs the insulative value of the snowcover. Increases in density dramatically decrease the insulative properties of the snowcover. Density of taiga api runs from about 0.05 (50 kg m^{-3}) to 0.15 (150 kg m^{-3}). It is very light and fluffy. In contrast, density of tundra upsik can run from about 0.15 (150 kg m^{3}) to 0.5 (500 kg m^{-3}).
- The insulating properties of taiga api result in the pukak layer being markedly warmer than the upper layers. This warmth allows animal and bacterial activity to proceed. Such activity releases carbon dioxide in the pukak space. If the api contains dense layers the upward flow of air can be retarded and the CO_2 can accumulate in concentrations up to 5 times ambient. This can result in behavioural changes in small mammals (Penny 1978; Penny and Pruitt 1984). These behavioural changes sometimes result in *Clethrionomys gapperi* shifting their home ranges away from the affected site and returning later when the subnivean CO_2 falls to ambient concentrations.

For determining density, choose an undisturbed vertical face of the api, brush and delimit the layers, measure and record thicknesses. Start with the topmost layer. Take the Swedish density box (preferred design) by the handle, hold the box horizontally and flip the end cover up. Push the open end of the box firmly into the api horizontally until the box is full. Be careful not to overfill or force more api into the box exceeding its measured

volume. Flip the end cover back over the end of the box. Pull the box out, scrape off any clinging snow, hang the box by the handle from the scales and note the weight. Be sure you suspend the scales by the top ring, not by holding the barrel. Subtract the tare of the box to get the weight of the enclosed snow. Divide this by 1000 to get the density. You may want to add some coils of wire solder to the handle in order to bring the tare to a figure easily divisible by 1000.

The Swedish density box is usable for densities up to about 0.25 (250 kg m^{-3}). For determinations above this density there are available strong, polished metal tubes, sharpened or cut into saw teeth at one end and with two small holes so that a wire loop can be attached for hanging the tube from the scales. Do not use a hammer or sledge to drive a tube into the cut face of a very hard profile because continued use will burr the butt end; carry a block of wood to use as a bumper or shield between the end of the tube and the driver.

Other Data to Record

Other characteristics useful to record are: temperature of the air, temperature of each layer, temperature of the pukak, grain type and size for each layer, subnivean plants and, of course, the standard records of date, time, weather, exact locale (UTM and/or GPS loci), vegetation type, substrate, under tree canopy or not, animal activity, name of observer.

I have found that the sample data form in Figure 2 is easy to use in the field. Make a master sheet with four replicates of the form, photocopy it as many times as required. One may use the 4× sheets held in a clip board or cut the individual forms apart with a paper cutter and keep them, in order, in a spring-loaded notebook.

One does not need to establish full api profiles. Some aspects of animal and plant winter ecology can be made clear with well-chosen hardness readings. For example, I observed (Pruitt 1984b) how Collared Lemmings *(Dicrostonyx groenlandicus)* made their tunnels through hard tundra upsik by excavating along a relatively soft layer floored and roofed with harder layers. It is clear that detailed knowledge of the natural history of the subject species will enable one to focus on critical features influencing its winter survival.

A "Snow Index" incorporates natural history and behavioural characteristics and correlates them with movement and behaviour of the species being considered in relation to several characteristics of the snow cover. For example, Pruitt (1959, 1981) showed that the distribution of *R. t. groenlandicus* on their winter range in northern Saskatchewan and south-central Northwest Territories could be correlated with and predicted by certain characteristics of the snow cover. Henshaw (1968) confirmed Pruitt's thresholds of sensitivity to the thickness and hardness of the snow cover in *R. t. granti* in northwestern Alaska. Stardom (1975) showed how the winter activity of *R. t. caribou* in southeastern Manitoba correlated closely with nival factors. Stardom also showed that the threshold of sensitivity to thickness was greater in *R. t. caribou* than in *R. t. groenlandicus.* Darby and Pruitt (1984) put the winter movements of *R. t. caribou* in the southeastern Manitoba taiga into perspective for that mid-continent taiga region.

Pruitt (1959) noted that the ideal nival winter range for *R. t. groenlandicus* had api that was thin, of little hardness and density, and that had not been affected by invasions of warm, moist air. In other words, their optimum winter habitat was in a cold, continental climate that enabled the heat and moisture to flow uninterruptedly from the earth through the api to the cold, dry air above. Deviations from this ideal situation result in worsening of over-wintering conditions for Caribou.

I combined hardness and thickness data (Pruitt 1979, 1981, 1989, 1990, 1992) of several layers in different combinations (based on several known aspects of Caribou winter ecology and behaviour) to arrive at what I call the Värriö Snow Index (VSI):

VSI = (H>H H b Tb + Vs Ts + Hh Th) T ta / 1000

Where H>H = Hardness of hardest layer more than halfway between the substrate and the top of the snowcover.

Hb Tb = Hardness times thickness of basal layer.

VsTs = Vertical hardness of surface layer times thickness of surface layer.

Hh Th = Hardness times thickness of hardest layer (if not H_b T_b).

(If basal layer is the hardest, then term Hh Th drops out.)

Tta = Total thickness of the api.

Most records of api hardness in relation to Caribou have been recorded in gm cm^{-2}. Pennycuick (1974) presented factors to convert to SI units.

This index models the relations with api of several subspecies of *Rangifer tarandus: (R. t. tarandus* [Pruitt 1979]*; R. t. groenlandicus* [Pruitt 1981]*; R. t. fennicus* [Pruitt 1989]; *R. t. caribou* [Schaefer 1990]) in Scandinavia and North America. Schaefer (1996) and Schaefer and Pruitt (1991) used these techniques to determine different qualities of Woodland Caribou winter range in Manitoba.

Raine (1983, 1987) devised a Snow Index that modelled the relations of Marten *(Martes americana)* and Fisher to the surface and upper layers of the api in the taiga of southeastern Manitoba. He found that these two closely-related sympatric species utilized the habitat differently, governed in large degree by the characteristics of the api. Fisher movements were restricted in midwinter by the presence of thick, soft api. At this time of the year Fisher travelled on trails made by Snowshoe Hares *(Lepus americanus)* and also their own trails more than at other times during the snow season. In midwinter, Fisher tended to walk through api and to leave a body drag. On the other hand, Marten appeared to be unhindered by soft api to the degree Fisher were. Marten tracks never showed a body drag

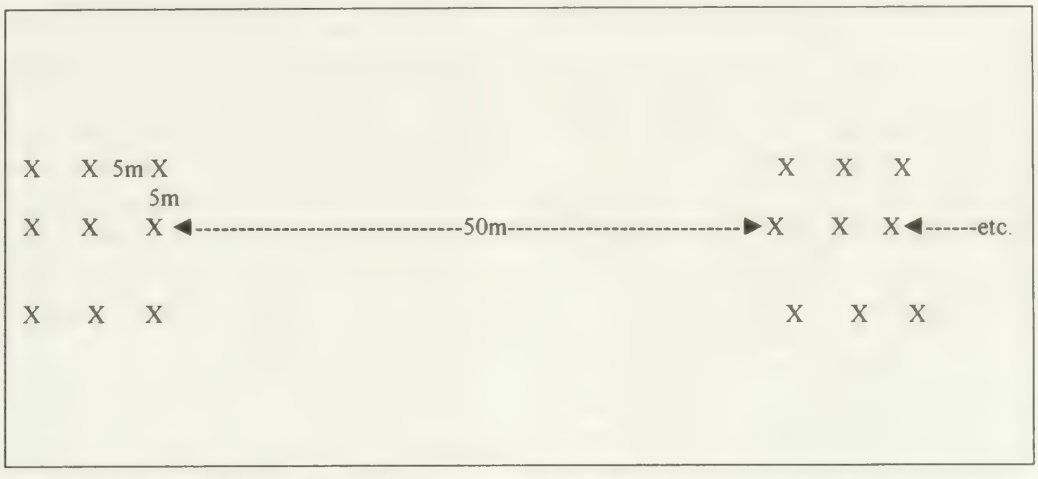

FIGURE 3. Technique of establishing a standardized survey of api thickness. Xs signify sites of actual thickness measurements.

in the api. They did use Hare trails and their own trails in midwinter but not to the extent Fisher did.

Raine's Snow Index (SI) for the top 10 cm of the api, in relation to Marten and Fisher is:

$SI = 1\,000 - \Sigma (T \times H)$

Where T = Thickness of the api in centimetres

H = Hardness of the top 10 cm in gm cm^{-2}

Both species were usually supported by H of 100 gm cm^{-2} [1 N]. This value was taken as the maximum hardness of any layer; therefore 1000 was the maximum value of the sum of the products. Any SI of near zero meant that both species could travel freely on the api surface, whereas an SI of 900 or more would perhaps indicate a hindering effect on their movements. Raine found that this SI modelled the responses of both Marten and Fisher to changes in api thickness and hardness. He also found that Fisher responded to increased SI by changing their gait while Marten were much less liable to.

There are two notable points brought out by Raine's study:

- Although these closely-related species used similar habitats in the same region they exhibited differences in habitat use associated with different responses to the api, thus allowing the two species to co-exist
- Their different responses to characteristics of the api enabled them to parcel out the food resources. Marten, being smaller and with less mass, are more subnivean, more arboreal and are more efficient predators on small mammals. Fisher, on the other hand, are better adapted to hunting larger prey such as Snowshoe Hares, Porcupines *(Erethizon dorsatum)* and ground-dwelling birds; indeed, they occasionally prey on Marten

Raine's study also demonstrated how detailed examination of the snowcover can clarify fundamental biological relationships. For example, a more parsimonious explanation of the mid-winter differences in habitat and behaviour of these two closely-related species is as energy-saving reactions (Formozov 1946) rather than curiosity, territorial or sexual interest as postulated by Marshall (1951) or Pulliainen (1980).

General Procedure

Sites for api profiles must be chosen according to criteria generated by the experimental design. For example, if the study is to test a null hypothesis "Snowcover (api) characteristics have no relation to Caribou overwintering sites" then one must sample the study region/area with two types of snowcover sites: "controls" which are spaced over the entire region either on a systematic grid (by relative area of available vegetation types) or by a randomization scheme, and "experimentals" which are related to actual Caribou feeding craters, resting sites or movement trails. The number of each is determined by the variance of the readings and the level of accuracy desired. It is as important to know the conditions where Caribou are *not* as to know where they *are*.

Thickness can vary widely. The more observation points on your study or sampling sites usually the better. One way of determining thickness is to establish permanent transects with permanent markers. For example, on a transect establish (before snow flies) "quadrats" of nine sampling points, points 5 metres apart in three rows of three points each (Figure 3). Mark each point with a thin wand having alternating bands of contrasting colour each 10 cm high plus a bottom section long enough to anchor the wand firmly into the substrate. Paint or mark the decimeter labels, oriented so that all can be seen from one spot outside the quadrat. Establish another quadrat nearby; this will be used for destructive sampling (api pits) for hardness, density and crystal characteristics. It should also be marked so that one is not liable to re-use the same pit for more than one sampling. Repeat such 9-point sampling sites every 50 m along the permanent transect (Figure 3).

Approach the thickness and hardness/density sites from the same direction each visit; this ensures that you do not attempt to resample the same site again. A wand or two will help to keep the sites differentiated. Frequently take record photos of the site. As a general rule, one can never take too many record photos. Use a standardized identification scheme to ensure the photos will be recorded correctly.

Mark your ski poles with rings of brightly coloured reflecting tape each 10 cm apart beginning at the tip of the hand grip. Use a pole, thrust handle-down, through the api to measure its thickness every 5 or 10 "ski steps" periodically as you move between sites.

If your study region is windblown (e.g., tundra or steppe) determining thickness may be difficult. Very frequently it can be impossible to thrust a ski pole, handle first, into the hard snowcover. You may need to carry a thin, sharpened metal rod marked in decimeters to penetrate the wind-hardened snowcover. In some instances you may need to dig a series of small pits to ground level in order to expose profiles of the snowcover.

An api profile site is usually excavated so that the vertical cut face of the pit in the snowcover is downwind and oriented so that the sun shines on it at about a 45° angle. This latter orientation is to emphasize the shadow relief of the snow crystals for photographic purposes. Differentiate and emphasize the layers of the api by gently stroking up and down with a wide, soft brush. Measure and record the thickness (T)(cm) of each layer of the api.

Precautions When Using a Snow Kit:

- Be sure to return instruments and discs to their proper place immediately after use. If you drop one into the api you may not find it until spring.
- Record your data immediately; don't trust your memory.
- Keep the kit cold so that the instruments are at ambient temperature when you use them.
- If snow gets inside the kit, brush out as much as you can. Carry a small hand-operated sucker pump in order to clean out all the snow. Take the kit into a warm, dry place, open it up, disassemble it and give it a chance to thaw and dry overnight.
- With ambient temperatures between +5° and -5° snow may stick to metal parts and later freeze them immobile. Dry off the push-rod, scales, density box, etc. frequently under these conditions.
- Avoid touching the metal parts with bare hands. In warm weather your hands heat up the parts while in cold weather you can get frost-nipped from handling the cold metal.

The Snow Kit has had a long, evolutionary history from its original form (Klein, Pearce and Gold 1950). It continues to undergo changes. I welcome comments and suggestions as to how it can be modified to be even more useful. The actual instruments and tools needed will vary with the proposed research. For instance, I have a "complete" kit of instruments and tools for general research and teaching. I have found that density is of little or no consequence to *Rangifer* movements but hardness definitely is. Therefore, in my "caribou kit" I have only thickness and hardness instruments and those for temperature and crystal size as well as type reference photos.

One source of these materials is from the Science Shop at Lakehead University, 955 Oliver Road, Thunder Bay, Ontario, Canada P7B 5E1 or "Ed Drotar" <ed.drotar@lakeheadu.ca>

All the instruments and tools will fit into various slots, holes and grooves in a block of fine-grain styrofoam inside a bright orange angler's "dry box," the lid of which is snubbed shut with a short length of bungee cord. My box fits nicely inside my rucksack. A short-handled, flat-bladed aluminum shovel is lashed to the ice-axe loop of my rucksack. With a hunk of cheese and black bread, a thermos of tea and my Lappish bush skis (as well as field notebook and camera) I am outfitted for a day of snow study.

So we see that using words from cultures more closely associated with snow than our relatively poverty-stricken English opens a different world to our view. Not only does specialized, precise terminology open a new world for us, but specialized measurements of characteristics of the snow cover such as duration, thickness, hardness and density add precision to our observations. These specializations mean greater understanding and appreciation of adaptations of mammals and birds (as well as plants) to a phenomenon (snow) characteristic of a significant portion (winter) of the annual cycle of the seasons.

It is also clear that the study of snow ecology will enable one to make significant contributions to the natural history of all animals and plants of northern regions. The tools are available, only the thematic shift is required.

Acknowledgments

About sixty classes of undergraduate and graduate students have participated in (suffered through?) long days of repeating snow stations at Taiga Biological Station during winter field trips in Mammalogy and in Boreal Ecology. Many of these students have gone on to their own research and teaching and have contributed to our knowledge of winter ecology of mammals and birds of the taiga and tundra. I am grateful to Spencer Sealy and James Hare for critical comments on an early draft of this paper as well as to two anonymous reviewers of the penultimate draft. Spencer Sealy also guided me through recent changes in the scientific names of some northern birds. My daughter, Cheryl Ann Pruitt, has contributed her exceptional editorial skills to clarify aspects of this report. As always, my wife and field companion, Erna, has kept the whole operation from falling apart. Most "Official" organizations and funding agencies have shown a remarkable lack of interest in supporting detailed winter ecological field studies in the taiga and tundra but Canadian Wildlife Service, Värriö Subarctic Research Station, Oulanka Biological Station and the Taiga Biological Station Research Trust have supported parts of this research, for which I am deeply grateful.

Visit the Taiga Biological Station Home Page (www.wilds.mb.ca/taiga) for references to other reports on the effects of snowcover on taiga animals and plants.

One of the outside reviewers of this paper has made a significant suggestion, because he has become "...increasingly dissatisfied with phrases such as "winter ecology", "snow ecology..." which present syntax problems such as "...Ecology of plants and animals in winter/snow..." He suggests a new word-combination to cover "the study of snow" on a par with "limnology", "entomology" and so on. This word-combination would be "chionology" and made up of "chion" (Greek for "snow") and "logy" (Greek for "knowledge of.") This word-combination would fit in nicely with the three words "chionophile", "chioneuphore", and "chionophobe" introduced by the great Russian naturalist (and "chionologist") Alexander Nikolaevich Formozov. I agree with the suggestion.

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Received 8 December 2003
Accepted 7 March 2005

Notes

Découverte de la Salamandre à quatre orteils, *Hemidactylium scutatum*, à Québec, Québec : limite nord-est de l'espèce sur la rive nord du fleuve Saint-Laurent

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Pouliot, Daniel, et Jean-François Desroches. 2005. Découverte de la Salamandre à quatre orteils, *Hemidactylium scutatum*, à Québec, Québec : limite nord-est de l'espèce sur la rive nord du fleuve Saint-Laurent. Canadian Field-Naturalist 119(1) : 129-131.

En 1999 trois spécimens de Salamandre à quatre orteils ont été observés à Québec, sur la rive nord du fleuve Saint-Laurent. Des recherches effectuées au même site en 2001 ont permis de découvrir d'autres spécimens de même que des pontes. Ces mentions élargissent la distribution connue de l'espèce de 90 km vers le nord-est-est et 80 km vers le nord-nord-ouest. Il s'agit vraisemblablement de la limite nord-est de cette salamandre, sur la rive nord du Saint-Laurent.

Mots-clés : Salamandre à quatre orteils, *Hemidactylium scutatum*, aire de distribution, extension d'aire, Québec.

In 1999, three Four-toed Salamanders were observed at Québec, north shore of the St. Lawrence River. Field searches in 2001 allowed the discovery of another specimen as well as egg clutches. These records extend the known range of the species 90 km north-east-east and 80 km north-north-west. This is probably the northeastern limit of this salamander's range on the north shore of St. Lawrence River.

Key Words: Four-toed Salamander, *Hemidactylium scutatum*, distribution, range extension, Québec.

Le 16 avril 1999, un adulte de la Salamandre à quatre orteils (*Hemidactylium scutatum*) a été découvert dans un boisé de la ville de Québec, dans l'arrondissement Sainte-Foy (46°45'31"N; 71°19'13"O) par l'un des auteurs (DP). Les 22 et 24 avril de la même année, deux autres individus adultes ont été découverts dans le même boisé urbain. La première salamandre observée était dissimulée à l'intérieur d'un tronc d'arbre pourri, alors que les deux autres étaient cachées sous des bûches, directement sur le sol. Aucun spécimen n'avait alors été récolté. L'habitat à cet endroit est une forêt mixte à dominance de feuillus. On y retrouve l'Érable à sucre (*Acer saccharum*), le Hêtre à grandes feuilles (*Fagus grandifolia*), le Chêne rouge (*Quercus rubra*), l'Érable de Pennsylvanie (*Acer pensylvanicum*), le Bouleau blanc (*Betula papyrifera*), le Sapin baumier (*Abies balsamea*), la Pruche du Canada (*Tsuga canadensis*) et le Bouleau gris (*Betula populifolia*). Le sol est recouvert d'une abondante litière de feuilles mortes et les débris ligneux y sont nombreux.

Le 11 mai 2001, nous sommes retournés sur le site afin notamment d'officialiser la présence de l'espèce à cet endroit par l'obtention de spécimens. Une recherche active effectuée entre 10h00 et 12h10 dans le boisé n'a pas permis d'y trouver la Salamandre à quatre orteils, mais 16 Salamandres cendrées (*Plethodon cinereus*) y ont été observées. C'est finalement dans un habitat adjacent, une Aulnaie à sphaigne, que cinq (5) Salamandres à quatre orteils adultes, de même que trois (3) masses d'œufs, ont pu être trouvées. Il s'agit des premières observations des œufs de l'espèce en milieu naturel au Québec. Deux spécimens adultes ont été récoltés et déposés au collection d'amphibiens et reptiles du Musée canadien de la nature (CMNAR-35712).

Les salamandres et les masses d'œufs étaient dissimulées dans des petits îlots de Sphaigne (*Sphagnum* sp.) enchevêtrés dans des racines d'arbustes, principalement des Aulnes rugueux (*Alnus incana* ssp. *rugosa*), et entrecoupés de petites mares formées par la fonte de la neige. Les plantes recensées dans cet habitat sont, outre les aulnes, le Chou puant (*Symplocarpus foetidus*), le Viorne cassinoïde (*Viburnum cassinoides*), le Viorne à feuilles d'aulne (*Viburnum alnifolium*), le Némopanthe mucroné (*Nemopanthus mucronatus*) et dans une moindre mesure l'Érable argenté (*Acer saccharinum*). Ce milieu correspond à un habitat de ponte typique pour l'espèce si l'on se fie à la documentation existante (Bishop 1941; Petranka 1998). Le boisé adjacent est un habitat utilisé en dehors de la période de ponte, possiblement pour l'alimentation et l'hibernation. Ce complément d'habitats terrestres et de ponte est nécessaire à la présence de la Salamandre à quatre orteils (Bishop 1941; Blanchard 1923).

La Salamandre à quatre orteils est une espèce discrète et difficile à repérer, qui a toujours suscité l'intérêt des herpétologistes. Même aujourd'hui, elle n'est connue que de peu d'endroits dans la province (figure 1) et y est considérée en péril (FAPAQ 2004*). Sa présence au Québec a été rapportée pour la première fois en 1953, près de Hull en Outaouais (Gorham 1955).

Jusqu'à récemment, la limite de distribution de la Salamandre à quatre orteils au Québec semblait se situer à l'ouest de la longitude 72°, dans la zone comprise à plus de 180 jours de croissance par an (figure 3 *dans* Bonin 1999 *). Toutefois, en 2000, un spécimen a été découvert au lac du Castor, dans la région de Chaudière-Appalaches, ce qui a étendu l'aire de distribution de cette salamandre de 160 km vers le nord-est et 145 km vers le sud-est (Desroches et Couture 2002). Cette mention fut la première en dehors de la zone de limite de croissance de 180 jours par an, au Québec. La nouvelle localité où fut découverte cette espèce en 1999, à Québec, est également située en dehors de cette zone.

La région de la ville de Québec constitue la limite de distribution de plusieurs espèces d'amphibiens et reptiles (voir les cartes de distribution dans Cook 1984; Bider et Matte 1991). À l'est de Québec l'altitude moyenne augmente considérablement, passant de 116 m à 411 m, et la saison de croissance passe de 170-180 jours à 150-170 jours (Robitaille et Saucier 1998). Le domaine de l'Érablière à Tilleul est remplacé par celui de la Sapinière à Bouleau jaune. Toutes ces différences reliées aux habitats et à la température portent à croire que la Salamandre à quatre orteils ne peut pas se retrouver beaucoup plus à l'est, sur la rive nord du Saint-Laurent, que le site découvert en 1999 à Québec.

Au Canada, on retrouve cette salamandre en Ontario, au Québec, au Nouveau-Brunswick et en Nouvelle-Écosse. Les mentions les plus nordiques au Nouveau-Brunswick et en Nouvelle-Écosse ont été faites à des latitudes semblables à celle de Québec (figure 2). En Ontario, la mention la plus nordique se retrouve à environ 220 km plus au nord (Bonisteel

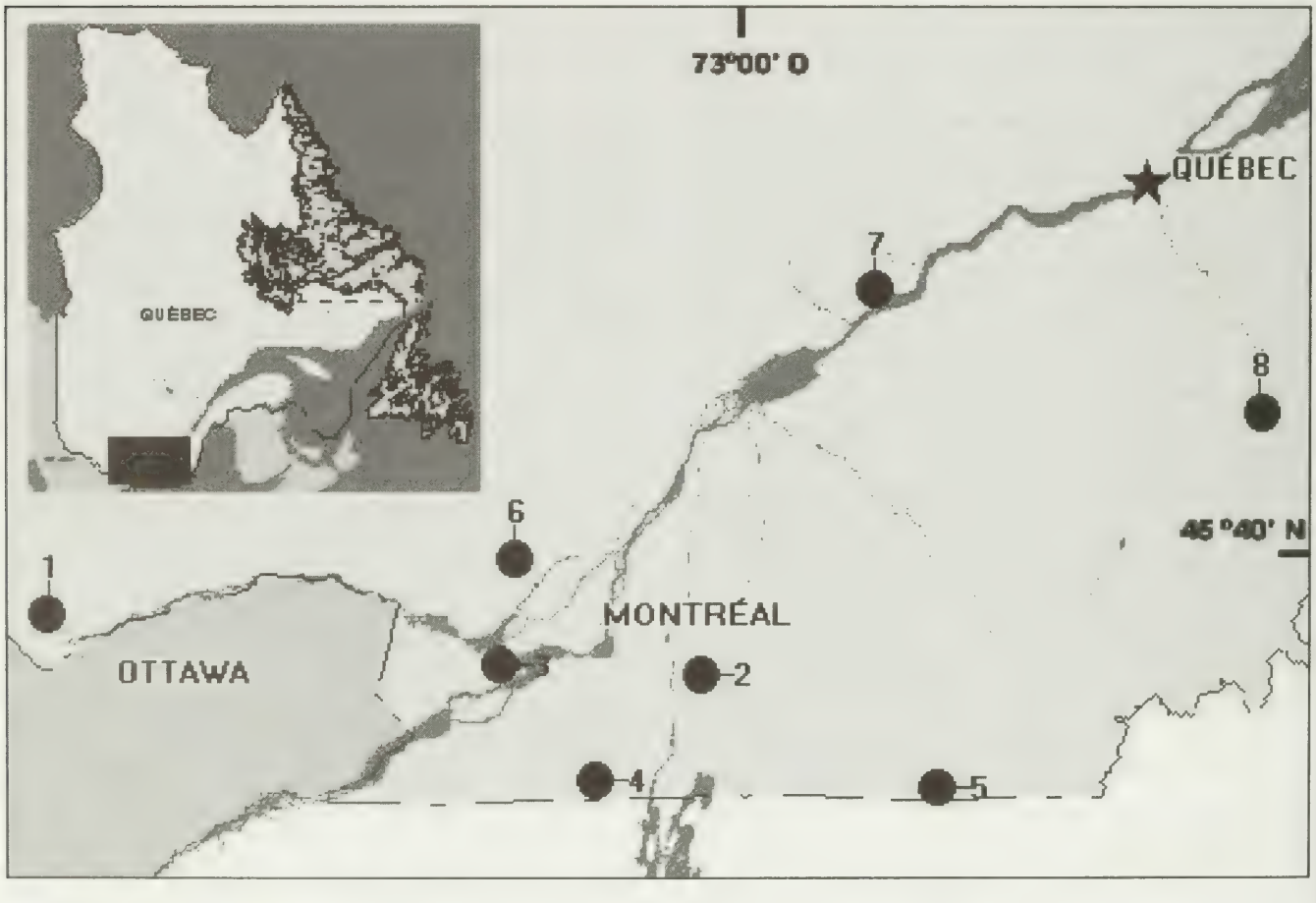

FIGURE 1. Sites où a été rapportée la présence de la Salamandre à quatre orteils au Québec, Canada. Les cercles noirs représentent les données historiques et l'étoile concerne le site de Québec. Cercles noirs = 1 Secteur de Hull (Gorham 1955), 2 mont Saint-Grégoire (Denman 1961), 3 Île Perrot (Denman 1965), 4 Covey Hill (Gordon 1979), 5 Marlington (Sharbel 1990), 6 Laurentides, au nord de Montréal (Bider et Matte 1991; CMNAR-33778), 7 Secteur de Trois-Rivières (Bider et Matte 1991; CMNAR-33773 et 33774), 8 lac du Castor, Chaudière-Appalaches (Desroches et Couture 2002). Étoile = Ville de Québec (le présent article).

FIGURE 2. Aire de distribution de la Salamandre à quatre orteils au Canada (modifié d'après : Cook 1984). Les numéros réfèrent aux mentions les plus nordiques pour chaque province. 1 : Ontario (Bonisteel 1973), 2 : Québec (le présent article), 3 : Nouveau-Brunswick (Woodley et Rosen 1988), 4 : Nouvelle-Écosse (Richmond 1952; Gilhen 1984)

1973). Ceci porte à croire que la Salamandre à quatre orteils pourrait se retrouver à des latitudes plus hautes au Québec, surtout dans l'ouest de la province.

Remerciements

Les auteurs remercient Nathalie Côté, Raphaël Demers, Ian-Érik Gosselin et Fannie Martin pour leur aide sur le terrain. Ils sont également reconnaissants envers Mario Darsigny, qui a réalisé la carte de localisations des mentions au Québec, et Francis R. Cook pour les informations obtenues au sujet de la Salamandre à quatre orteils au Canada.

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Received 8 October 2003
Accepted 21 February 2005

Use of a Bridge for Day Roosting by the Hoary Bat, *Lasiurus cinereus*

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Hendricks, Paul, Joseph Johnson, Susan Lenard, and Coburn Currier. 2004. Use of a bridge for day roosting by the Hoary Bat, *Lasiurus cinereus.* Canadian Field-Naturalist 119(1): 132-133.

The Hoary Bat *(Lasiurus cinereus)* is a migratory species with the widest distribution of all New World bats. It is a solitary species that roosts during the day and night primarily among tree foliage. During a survey of 130 highway structures (bridges and culverts) in south central Montana for evidence of use by bats, we discovered a female Hoary Bat with young in mid July 2003 using a wooden bridge as a day roost. This is the first report of Hoary Bats using a bridge as roosting habitat.

Key Words: Hoary Bat, *Lasiurus cinereus,* roosting, habitat, bridge use, Montana.

The Hoary Bat *(Lasiurus cinereus)* has the widest distribution of all New World bats (Shump and Shump 1982). Across their range males and females tend to roost alone (Constantine 1966; Barbour and Davis 1969; van Zyll de Jong 1985; Nagorsen and Brigham 1993). Roosting individuals are encountered infrequently in deciduous and coniferous tree foliage, the preferred roosting habitat, and much remains to be learned about their roosting habits.

During July and August 2003 we examined 130 highway structures (bridges and culverts) in Carbon, Stillwater, and Yellowstone counties, south central Montana, for evidence of use by bats as day or night roosts. Twelve bridges were used as day roosts by four species of bats. Two bridges supported maternity colonies of Little Brown Myotis *(Myotis lucifugus),* and two harbored maternity colonies of Big Brown Bats *(Eptesicus fuscus).* We estimated these colonies included 15-90 adults; at the remaining eight bridges we found 1-8 individual bats. Bat species present among the 12 bridge day roosts included Big Brown Bat at ten, Little Brown Myotis at two, Western Small-footed Myotis (M. *ciliolabrum)* at two, and Hoary Bat at one.

On 16 July at about 11:00, we discovered a female Hoary Bat roosting in a bridge spanning Shane Creek (45°36'42.7"N, 109°16'48.7"W; 1125 m elevation) on Montana Highway 78, about 4.8 km S of Columbus, Stillwater County. She was wedged in a tapering 4 cm wide slot (ca. 20 cm deep) between two wooden girders on the underside of the bridge 5.3 m above bare ground (Figure 1); only a shallow narrow channel of water was flowing under the bridge at the time. Using an 8× binocular and spotlight we could see at least two naked pups partially exposed and crawling under her folded wings. A maternity colony of about 15 adult Big Brown Bats occupied the same slot 1.5 m from the female Hoary Bat but where the slot was slightly narrower.

The bridge was a two-lane wooden girder design (19.8 m long) with an asphalt deck surface, and provided roosting sites similar to some railroad bridges (see Davis and Cockrum 1963). Vegetation adjacent to the bridge included a riparian strip of Plains Cottonwood *(Populus deltoides)* and willow *(Salix* sp.), and pasture intermixed with rural home development; nearby sandstone bluffs supported open stands of Ponderosa Pine *(Pinus ponderosa).* We revisited the bridge the two days following discovery of the female Hoary Bat, as well as on 18 August, 9 and 16 September, but no Hoary Bat was present on any of these days, although about 15 Big Brown Bats continued to use the bridge as a day roost until the last date, when none was present.

Records of Hoary Bats roosting in sites other than tree foliage are unusual, and use of man-made structures is rare. Appearance in caves is the most frequently reported alternative roost site, but Hoary Bats found in caves usually are dead or dying individuals (Mumford 1953; Beer 1954; Myers 1960). Other reported roosting sites include a squirrel nest, a woodpecker cavity, a tree hollow, a driftwood plank, a cellar door, and the side of a building (Bailey 1936; Neill 1952; Shump and Shump 1982; Nagorsen and Brigham 1993).

Use of bridges by Hoary Bats for day or night roosting has not been reported previously in the literature. Ellison et al. (2003) mention collection of a Hoary Bat at a bridge, but this is based on a specimen (MSU5676 at Montana State University, Bozeman) taken at "Shedd's Bridge" in Gallatin County, Montana on 11 September 1964; no data associated with the specimen indicate that it was roosting in the bridge. The Hoary Bat was not among the 17 bat species found during a broad survey of 2421 highway structures (bridges and culverts) across the western and southern United States (Keeley and Tuttle 1999). Studies of smaller samples of bridges in Arizona, northern California, and the Oregon Coast Range also did not report the presence of Hoary Bats (Davis and Cockrum 1963; Pierson et al. 1996; Adam and Hayes 2000).

Lack of prior reports of Hoary Bats using bridges for roosting (Shump and Shump 1982; Pierson et al. 1996; Keeley and Tuttle 1999) indicates that bridge use by this species is a relatively rare occurrence. The Hoary Bat is a solitary roosting species that switches roosts frequently (Lewis 1995); this could make detection of their use of any particular highway structure highly unlikely. Bridge surveys often involve only one or a few

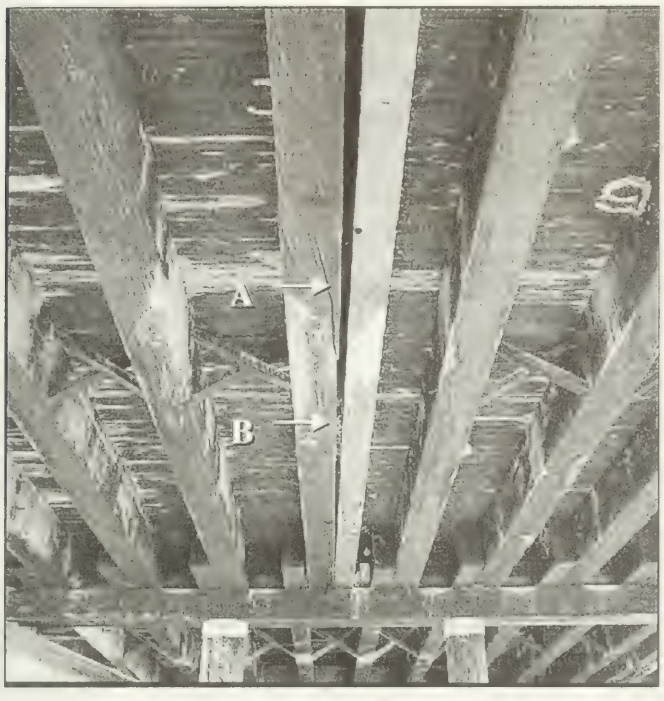

FIGURE 1. Underside of wooden bridge spanning Shane Creek, Stillwater County, Montana, showing July 2003 day-roost locations of a female Hoary Bat (A) and a maternity colony of Big Brown Bats (B).

visits to specific structures (Davis and Cockrum 1963; Keeley and Tuttle 1999; Adam and Hayes 2000; this study), or else monitor activity more intensively at a small number of structures (Davis and Cockrum 1963; Pierson et al. 1996; Adam and Hayes 2000); the number of bridge visits or scope of intensive surveys may be inadequate to detect an extremely low frequency of bridge use by the Hoary Bat. Studies that focus on bridges known to be used as night roosts (Pierson et al. 1996; Adams and Hayes 2000) may overlook Hoary Bats if their use of bridges is more likely during the day, the time when we made our observation. Thus, low roost site fidelity and a solitary nature may make detecting the rare occupancy of bridges by Hoary Bats even more problematic if only single visits to bridges are made during daytime surveys, or studies are focused primarily or exclusively on night roost dynamics.

Acknowledgments

Our observations were made during a cost reimbursement contract (MDT Project #8159) between the Montana Department of Transportation and Montana State Library-Natural Resource Information System/ Montana Natural Heritage Program. The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Montana Department of Transportation or the Federal Highway Administration. We thank Susan Sillick (MDT) and Jim Hill (NRIS) for administering this contract, and Larry Urban (MDT) for being receptive to the initial idea. Laura Ellison (US Geological Survey) identified the source of their bridge use record. Our paper benefited from the comments of two reviewers.

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Received 25 March 2004
Accepted 28 January 2005

Aggressive Behaviour Exhibited by a San Joaquin Kit Fox, *Vulpes macrotis mutica*

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Clark, Howard O., Jr. 2005. Aggressive behaviour exhibited by a San Joaquin Kit Fox *Vulpes macrotis mutica*. Canadian Field-Naturalist 119(1): 134.

While placing a hairtube-trapping device near a Kit Fox natal den, I observed a juvenile Kit Fox exhibit aggressive behaviour towards my presence. Although Kit Foxes usually are not aggressive, my observation demonstrated that some Kit Foxes defend their natal dens when alarmed.

Key Words: San Joaquin Kit Fox, *Vulpes macrotis mutica*, aggressive behaviour, natal den, California.

Kamler et al. (2000) reported an incident where a juvenile male Swift Fox (*Vulpes velox*) exhibited aggressive behaviors toward researchers. Like the Swift Fox, Kit Foxes are usually acquiescent and do not readily display aggression toward humans (when not trapped). Similar to the observations of Kamler et al. (2000), I witnessed the aggressive behaviour of a radio-collared juvenile Kit Fox as I was placing prototype hairtube traps (Clark et al. 2003) in the vicinity of its natal den. As I was placing the trap, the male pup aggressively approached me with a series of sharp barks. He circled around me within 3 m – sniffing and barking. He then stuck his head into the hairtube trap twice while I was watching him, but did not remove any bait. He continued to pace around me and bark for about 10 min. This observation occurred at 20:45 on 25 May 1999, along the California Aqueduct, near Lost Hills, Kern County, California, 35°36.98'N, 119°41.66'W (WGS84/NAD83). It was dark at the time; sunset was at 20:03. The natal den was being used by two adult (male and female) Kit Foxes and three male pups. All five Kit Foxes were radio-collared, with the juveniles being trapped and radio-collared on 3 May 1999.

It appeared that the juvenile was protecting the natal den area and was curious to discover my reaction toward his aggressive approaches. Aggressive foxes that readily approach potential danger might experience a higher rate of mortality than those that select to run and take cover in dens. By November 1999, two of these juveniles were killed by Coyotes (*Canis latrans*) and one had presumably dispersed (Clark 2001). Coyotes are a common source of mortality for Kit Foxes (Ralls and White 1995). My observation suggests that some Kit Foxes will defend their natal areas and aggressively approach potential threats to themselves and family members, as also described in Kamler et al. (2000).

Acknowledgments

The California Department of Water Resources gave permission to enter the California Aqueduct right-of-way. Funding of this note provided by the U.S. Department of the Interior, Bureau of Reclamation. J. Clark also witnessed the fox interaction.

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Received 29 March 2004
Accepted 7 March 2005

An Ancient Wolf, *Canus lupus*, Den and Associated Human Activity in the Southwestern Yukon Territory

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Farnell, Richard, P. Gregory Hare, and Daniel R. Drummond. 2005. An ancient wolf den and associated human activity in the southwestern Yukon Territory. Canadian Field-Naturalist 119(1): 135-136.

The recovery of an ancient hunting artifact in an active Wolf den indicates that Wolf denning sites may be reused for many centuries. It also suggests that traditional practices of predator management by humans may have great antiquity.

Key Words: Wolf, *Canis lupus*, den, archaeology, bow and arrow, Yukon.

Yukon Wolves, *Canis Lupus*, typically dig dens in May to rear pups (Rausch 1967). They may occupy the same den for several consecutive years or intermittently over long periods; however, the long-term persistence of Wolf dens in the Yukon has not been explored. The recent recovery of an antler arrow point within a Wolf den provides evidence that Wolves may return to the same denning sites over many centuries.

In May 1995, during a routine monitoring visit to a Wolf den in a remote area of southwestern Yukon, DRD [Daniel R. Drummond] entered an entrance tunnel leading to the main chamber (Figure 1). Here, he found and extracted a barbed antler point that was embedded in the tunnel side-wall near the tunnel entrance. The projectile point is typical of a style of point used by Southern Tutchone hunters throughout the past 1200 years (Hare et al. 2004) (Figure 2). The artifact was submitted to Beta Analytic Laboratories for AMS radiocarbon dating and returned a date of 850 ± 50 B.P. (Beta-162350).

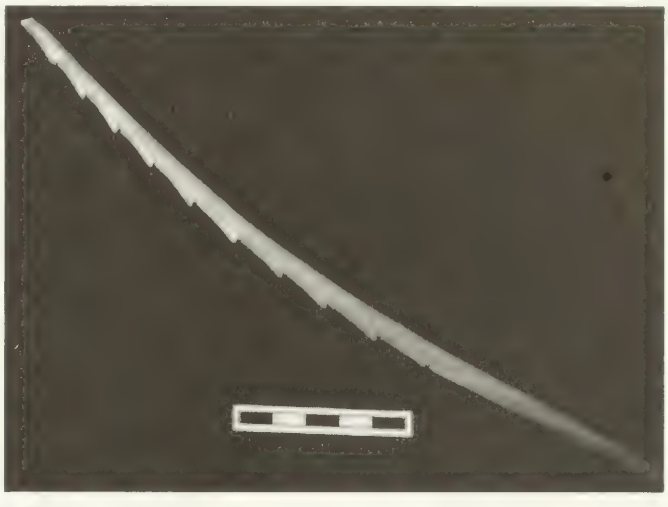

FIGURE 2. Photo of barbed antler arrow point (scale bar in centimeters).

FIGURE 1. Photo of D. Drummond examining entrance of Kloo Lake den tunnel.

This date provides evidence that the den was in use by at least 1040 to 1270 AD (calibrated, 2 Sigma variation). While there was significant amount of bioturbation at the site, the excellent preservation of such a fragile, organic artifact indicates that the projectile point has remained in buried, dry conditions for most of that entire period.

The southwest Yukon den (61°N 5', 137°W 54') is known as the Kloo Lake den. It was monitored annually for reproductive activity from 1992 to 1998 for a Wolf fertility control experiment (Spence 1998). The den characteristics are typical of those found in Yukon and Alaska (A. Baer, Yukon Department of Environment, unpublished data; Ballard and Dau 1983). The den site is well suited for Wolves. It has a southern exposure and is situated on an old elevated river terrace composed of very stable frost-free lacustrine soils. It is located in a mixed open stand of spruce (*Picea* spp.), Trembling Aspen (*Populus tremuloides*), and willow (*Salix* spp.). It overlooks a large valley composed mostly of wetland traversed by the Jarvis River which flows into Kloo Lake 13 km downstream. There is substantial prey available in the area as it is situated in close proximity to calving and summer habitats of Woodland

Caribou (*Rangifer tarandus caribou*) and Moose (*Alces alces*) (Hayes et al. 2003). Caribou in particular are known to have occurred in the area in large numbers for at least 8000 years (Farnell et al. 2004).

There are several possible explanations to account for a barbed antler projectile point at this Wolf den. An ancient hunter may have lost the projectile point while "Wolf denning" or attempting to kill a wolf to use the hide for clothing many centuries ago. Alternatively a Wolf or other predator or scavenger could have transported prey remains with the point embedded from a previously wounded animal. Likewise, a hunter could have wounded a Wolf that subsequently returned to the den site. There is also the possibility that a hunter may have inadvertently dropped the projectile point at this location.

It is possible that the Wolf den was recently constructed on top of an archeological site that contained an antler point but this situation is highly unlikely. Two site inspections (2002 and 2003) of the Wolf den demonstrated that despite large surface exposures and sediment upheaval there was no other archeological evidence at the site (e.g., lithics, burned bone, charcoal, fire cracked rock).

Knowledge of historical locations of Wolf dens and the cultural and the traditional practice of "Wolf denning" (e.g., culling or capturing Wolf pups at dens during spring) is documented in both Yukon First Nation oral history and ethnographic documentation (Johnson 1994*; Allen 1993*; LeGros 1981*; Art Johns, Carcross/Tagish First Nation elder personal communication to R. Farnell, Tom Smith, Kaska Dena elder, commentary in Northern Native Broadcastings, "The Come Back Trail" 1988; Percy Henry, Tr'on dek Hwech'in, elder testimony to Alaska Board of Game, Anchorage, Alaska 1998). If the recovery of an 850-year-old arrow point within a den is related to the practice of "Wolf denning", it indicates that it is a traditional practice of long standing. It is also possible that it resulted from an effort to obtain Wolf pelts for use in clothing. However this seems unlikely as Wolf pelts are in extremely poor condition during spring and summer.

In view of the persistence of Wolf den reuse, it is possible that native hunters could have used predictable denning behavior to reduce interspecific competition for common prey. There is a large body of evidence that Wolves limit Caribou and Moose numbers (Hayes et al. 2003). At the same time, Moose and Caribou were critical to the survival of subarctic Southern Tutchone. Reducing Wolf numbers at dens would have improved the likelihood of success in hunting.

Mech and Packard (1990) first reported evidence for possible use of a Wolf den spanning a period of 700 years or more on Ellesmere Island, Northwest Territories based on fossil prey remains. On Ellesmere, Wolves cannot dig dens because of permafrost. The Ellesmere denning site was a cave and there are few in the area making it a uniquely suitable location. In Yukon, den longevity must rely on substrate stability and suitable regional prey availability—conditions that must have persisted at the Kloo Lake den for many centuries. At our latitude Wolves have many options for places to den; yet a surprising proportion of dens are reused. It may be that wolves are attracted to places previously used by other Wolves and this is an important factor in the continued use of some dens.

Acknowledgments

The Yukon Department of Environment and Department of Tourism and Culture supported this study. Suggestions provided by Robert O. Stephenson, Alaska Department of Fish and Game, Fairbanks, and Layne G. Adams, U. S. Geological Survey, Alaska Science Center, Anchorage are greatly appreciated.

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Received 26 January 2004
Accepted 21 February 2005

Papillate Watermeal, *Wolffia brasiliensis*, in Eastern Ontario: An Addition to the Flora of Canada

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Thomson, E. R. 2005. Papillate Watermeal, *Wolffia brasiliensis*, in eastern Ontario: An addition to the flora of Canada. Canadian Field-Naturalist 119(1): 137-138.

Wolffia brasiliensis is reported from eastern Ontario, at several sites within Frontenac and Lanark Counties. This is the first published record of *W. brasiliensis* in Canada.

Key Words: *Wolffia brasiliensis*, *Wolffia papulifera*, Watermeal, range extension, new record, Ontario, Canada.

Wolffia (Watermeal) is a small genus in the Lemnaceae (Duckweed Family) which consists of about 11 species and includes the smallest known flowering plants in the world. According to Scoggan (1978), Boivin (1967), and Dore (1957) only two species occur in Canada: *Wolffia columbiana* Karsten (reported by Scoggan and Boivin as *W. arhiza* Wimm.) and *W. borealis* (Engelm.) Landolt (referred to as *W. punctata* by Scoggan, Boivin, Dore and other American authors). Both species occur, often together, in eastern Ontario (Dore 1957; Newmaster et al. 1998). A third species, *W. brasiliensis* Weddell (= *W. papulifera* C. H. Thompson), has a range which extends from South America north to the eastern United States where it approaches the Canadian border (Landolt 2000). It has been found as far north as Berrien County, Michigan, and the shore of Lake Erie east of Cleveland, Ohio (Hess 1986; Dore 1957).

While conducting a botanical survey near Garter Lake, Bedford District, Frontenac County, Ontario, on 28 June 2003, I came upon a small, shallow beaver pond with *Wolffia* growing on the surface. The fronds of these plants were flattened on top as in *W. borealis*, but each bore a single, distinct papilla in the middle of the upper surface (Figure 1). The apex of the frond was rounded in dorsal view, matching the description of *W. brasiliensis*, rather than that of the acutely pointed *W. borealis*.

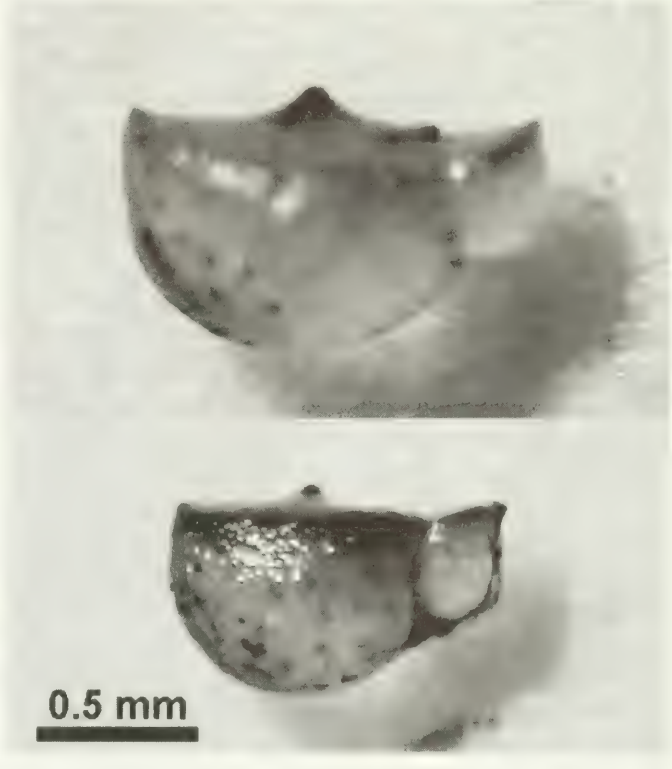

FIGURE 1. Vegetative fronds of *Wolffia brasiliensis* from Frontenac County, Ontario, showing central papilla. Photograph by Stephen J. Darbyshire.

No published record of *W. brasiliensis* in Canada has been found. (Reports of *W. brasiliensis* from Ontario, including that of Kartesz (1999), are based on *W. borealis* (Dore 1957; Morton and Venn 1990).) As well, in the DAO herbarium (acronym according to Holmgren et al. 1990), no *W. brasiliensis* was detected in collections of the closely related *W. borealis*, athough, as Dore notes, it is difficult to distinguish between them in the dry state. There is, however, a single specimen there of *W. brasiliensis*, collected on 10 September 1964 by Isabel Bayly, which has interesting label data [DAO 717812]. Although the collection was made in the greenhouse at Carleton University, Ottawa, from "dense vigorous growth in aerated aquarium with *Eichornia* [sic]", the original material was said to have come from an "artificial pond caused by a construction error, flooded 8-10 years previously", near Christie Lake, in Lanark County, Ontario. It is interesting to note that Christie Lake is only about 20 km from the Garter Lake site.

Situated in a predominantly deciduous forest, the Beaver pond near Garter Lake was edged with Woolgrass (*Scirpus cyperinus*) and Bristly Sedge (*Carex comosa*) and contained a variety of water plants including Watershield (*Brasenia schreberi*), Greater Bladderwort (*Utricularia macrorhiza,* Bur-reed (*Sparganium americanum*), and Coontail (*Ceratophyllum demersum*). Mixed in with the *W. brasiliensis* were a few plants of *W. columbiana.* Over the summer of 2003, the colony increased in size. Whereas on 3 July it had

covered an area about 10 m^2 of the pond's surface, by 16 September it covered an area of about 40 m^2. The ratio of abundance of the two species appeared to remain fairly constant.

Further surveys produced additional findings of *W. brasiliensis* in the same general area of Frontenac and Lanark Counties (see Appendix). Six locations were checked where patches of *Wolffia* were present. *Wolffia brasiliensis* was present in five of them, and in each of these five populations, it was the predominant species. The populations were found in a variety of quiet, shallow-water habitats, including beaver ponds, cattail marshes, and an old, beaver wetland of grasses, sedges and holly. At all sites, *W. columbiana* was also present but in lower numbers. At both sites on Briggs Lane (collections 3 and 4), some *W. borealis* was also found mixed with the other two species. In collection 7, from 16 October, a few plants of *W. brasiliensis* were in flower. The style with its dark stigma was clearly visible protruding from the floral cavity. On some individuals, the single anther could also be seen, still within the cavity.

Has *Wolffia brasiliensis* spread to this area recently, or has it been growing here unnoticed for years? The Bayly collection from 1964 seems to suggest the latter. The similarity of this species to *W. borealis* could cause it to be easily overlooked. Judging from the several locations found, the farthest ones being about 20 km apart, it seems unlikely that it is a recent, isolated, chance introduction by waterfowl. Rather, it appears to be well established in the area.

Acknowledgments

I am indebted to Stephen Darbyshire of Agriculture and Agri-Food Canada, who provided encouragement and generous assistance in many ways, including preparing the herbarium specimens, photographing the plants, locating reference material, and reviewing of the manuscript.

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Received 8 November 2003
Accepted 23 February 2005

APPENDIX

Collections of *Wolffia brasiliensis* from Ontario deposited in the herbarium of Agriculture and Agri-Food Canada, Ottawa (DAO).

1. Frontenac County, Bedford District, Garter Lake, UTM: 18T 0377173 4941383 [44°37'02"N, 76°32'53"W]; growing in a small, shallow beaver pond on stream flowing into Garter Lake; E. R. Thomson, 3 July 2003 (DAO 792125)
2. Frontenac County, Bedford District, Garter Lake, UTM: 18T 0377173 4941383 [44°37'02"N, 76°32'53"W]; growing in a small, shallow beaver pond on stream flowing into Garter Lake; E. R. Thomson, 12 July 2003 (DAO 792123)
3. Frontenac County, Bedford District, west of Wolfe Lake, Briggs Lane, UTM: 18T 0379606 4948662 [44°41'01"N, 76°31'05"W]; very abundant around the edge of a cattail marsh; E. R. Thomson, 17 September 2003 (DAO 792124)
4. Frontenac County, Bedford District, west of Wolfe Lake, Briggs Lane, UTM: 18T 0378843 4948442 [44°40'53"N, 76°31'42"W]; thickly covering a shallow pond; mostly *W. brasiliensis* with some *W. columbiana* and a few *W. borealis*; E. R. Thomson, 24 September 2003 (DAO 792121)
5. Lanark County, south of Christie Lake on Althorpe Road, 200 yards west of Hanna Road, UTM: 18T 0385598 4959533 [44°46'56"N, 76°26'43"W]; cattail marsh / pond; E. R. Thomson, 26 September 2003 (DAO 792122)
6. Frontenac County, Bedford District, west of Wolfe Lake, UTM: 18T 0379874 4949264 [44°41'16"N, 76°30'52"W]; small patches of open water in an old beaver wetland of grasses, sedges and holly; E. R. Thomson, 26 September 2003 (DAO 792120)
7. Frontenac County, Bedford District, west of Wolfe Lake, UTM: 18T 0380368 4950143 [44°41'46"N, 76°30'33"W]; shallow old beaver pond; mostly sterile fronds, a few fertile fronds; E. R. Thomson, 16 October 2003 (DAO 792258)

Record Size Female Coyote, *Canis latrans*

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Way, Jonathan G., and Robert L. Poietto. 2004. Record size female Coyote, *Canis latrans*. Canadian Field-Naturalist 119(1): 139-140.

On 11 March 2004 we recaptured and re-radio-collared an 8-9 yr old, 25.1 kg (55.3 lb), 157 cm long (tip of nose to tail tip) female Eastern Coyote (*Canis latrans*) in the town of Barnstable on Cape Cod, Massachusetts, that was originally captured in November 1998. This is believed to be the largest female Coyote ever recorded

Key Words: Eastern Coyote, *Canis latrans*, body size, Cape Cod, Coyote, Massachusetts, urbanization, weight

Coyote (*Canis latrans*) body weights are variable. They typically weigh 8.2 - 13.6 kg in the western part of their range, about 13.6 kg in the Midwest United States, and 15.9 – 18.2 kg in the northeastern part of its range (see Parker 1995 [and sources within] and Young and Jackson 1951). Parker (1995) reported record weights of Coyotes in the northeastern United States as 25.9 kg from Nova Scotia and 25 kg (Prince Edward Island) for two males and 23.4 kg (Nova Scotia) for a female, but this animal was suspected (based on breeding season) of being a Coyote-Dog (Coy-dog) hybrid. Dobie (1947) reported large specimens from California (30.9 kg) and Wyoming (32.3 kg). Young and Jackson (1951) described a 24.3 kg Coyote from Michigan and one weighing 34.0 kg from Wyoming, which was 160 cm long. All Coyotes were reported as fat males (except for the female Coy-dog that Parker reported); however, reported values could be suspect because all data came to those authors secondhand. For example, it is not known if Dobie and Young and Jackson were referring to the same Coyote (with a different weight given from each source) from Wyoming. Finally, JGW (Unpublished data) hand-raised a wild-born male Coyote from Cape Cod, Massachusetts, that fluctuated between 22.7 – 25 kg between the Coyote's first and second year of life. The literature rarely reports Coyote weights exceeding 22.7 kg (50 lb) and apparently never has for a female.

The Coyote dubbed "Casper" (Way 2000 – ID# 9804) was originally captured in a box trap (Way et al. 2002a) in November of 1998 within the town of Barnstable on Cape Cod, Massachusetts. She was a robust 2.5 or 3.5 yr old female that weighed 23.2 kg and was 148 cm long (tip of nose to tailtip) at the time. She was recaptured on 6 March 1999 and released without being handled. On 26 July 1999 she was recaptured and re-collared and weighed 19.6 kg and was 140 cm long. She was visibly skinny having raised ≥ 4 pups that summer (Way et al. 2001). She tested negative for heartworm (L. Venezia, Hyannis Animal Hospital, unpublished data). On 11 March 2004 we recaptured 9804 ca. 0.5 km from her original capture location (and in the core part of her territory: Way et al. 2002b) and replaced her old radio-collar (the battery had been dead for two years). She weighed (on a digitally calibrated scale) 25.1 kg (55.3 lb) and was 157 cm long (body length [nosetip to tailbone] = 108 cm). She was robust with plenty of fat (i.e., her hip bones were difficult to palpate), her stomach had ~ 2.3 kg of meat scraps (i.e., bait used to capture her), and she was 4 - 5 weeks pregnant, based on a physical exam and her prior denning habits (Way et al. 2001). Her canine teeth (0.8 – 1.2 cm) were worn to about half their original length. Despite her noted vigor, she tested positive for Lyme's disease and heartworm (L. Venezia, unpublished data). Nevertheless she had been the breeding female of a pack of ≥ 3 – 4 Coyotes (not including pups) for ≥ 6 years (Way et al. 2002b).

Coyotes from the New England region are large (Silver and Silver 1969; Wayne and Lehman 1992) and various theories for this have been postulated (Thurber and Peterson 1992) with hybridization from a small species of Wolf (*Canis lycaon*) a very plausible reason (Gompper 2002; Wilson et al. 2003). Coyote #9804 could not be a Coy-dog because she consistently gave birth in early April which is when wild canids normally whelp (Parker 1995; Way et al. 2001); Coy-dogs have a phase shifted reproductive cycle and typically whelp 2 – 3 months prior to wild coyotes (in mid-winter: Mengel 1971). Coyote #9804's blood is currently being analyzed (B. White, Trent University, unpublished data) to determine the genetic makeup of this unusually large sized Eastern Coyote.

Acknowledgments

This study would not have been possible without the support from L.Venezia and his staff at the Hyannis Animal Hospital, equipment purchases from E. Strauss and Boston College, Green Grant Youth Council support, and in-kind donations from the Way family. Two anonymous reviewers provided helpful comments on the manuscript.

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Received 10 May 2004
Accepted 28 February 2005

Book Reviews

ZOOLOGY

Amphibiens et reptiles du Quebec et les maritimes

By Jean-Francois Desroches et David Rodrigue. 2004. Editions Michel Quinton, Waterloo, Quebec J0E 2N0. 288 pages. Can $40.00.

The eye of the reader is quickly overwhelmed by blaze of sharp, high quality colour photographs throughout virtually every page of the body of the text, pages 11 to 235. These are the combined work of 20 photographers, with the authors contributing the majority, DR credited with 97 and J-FD with 42 compared to 103 by all others. This section covers preface, forward, introduction, definitions of amphibian and reptile, a code of ethics for herpetologists, observation and conservation of amphibians and reptiles, introduction to each major grouping within the two classes and individual species accounts. The latter include description, similar species, reproduction, habitat, critical area, food, predators, status, notes. These accounts demonstrate the authors' familiarity with the varied characteristics and ecology of each species.

A map covering from the western border of Ontario to the Maritimes and the adjacent northern United States depicts each species range in a splash of red. Those for the Quebec portion are drawn from the comprehensive database of the Quebec Atlas for which Rodrique is now the chief coordinator. This project is based at the St. Lawrence Valley Natural History Society and has financial supported from la Societe de la faune et de la parcs du Quebec. The data for the Maritime maps was provided by Don McAlpine at the New Brunswick Museum. The only problem with these is that the maps are too small allow detail and disjunct populations are easily overlooked.

In all, 40 species are given detailed treatment (21 amphibians and 19 reptiles (nearly half of the species total for Canada). Two sea turtles are not recorded for Quebec and two frog species, two freshwater turtles and two snakes are absent from the Maritimes. An additional account covers the complex subject of diploid and polyploid salamanders involving hybridization between species of the genus *Ambystoma*. Three more reptiles are either introduced (Red-eared Slider turtle, Eastern Box Turtle) or reported but not confirmed (Timber Rattlesnake).

Pages 236 to 288 conclude the book. These include diagrams of key features and identification keys to adults of both amphibians and reptiles, a standard in many guides. But in addition, there are keys to amphibian eggs, salamander larvae, tadpoles (frog larvae), and cast skins of snakes, subjects often poorly covered or omitted in other guides. Conservation is emphasized with a tables presenting the number of individuals for each of the nine common native species which can be held without permit in captivity in Quebec (two salamanders, toad, five frogs and the garter snake). Another table gives the status assigned to species whose continued survival is of most concern in Quebec, New Brunswick, and Nova Scotia. Groups coordinating observations of amphibians and reptiles in each of these provinces are also listed with addresses. Additional appendices cover the etymology of all scientific names and a glossary of 100 technical terms from "aire de repartition ou de distribution" to "zooplancton". Although this, like the entire text, is in French, it facilitates the reading of the book for anyone with at least a rudimentary grasp of the language.

The bibliography is arranged by guides and books, journal articles, and technical reports. The latter is particularly valuable as it includes work not widely referenced elsewhere. The Quebec literature is particularly comprehensive but the Maritime references are more sparse due to the greater familiarity of the authors with the literature of their native Quebec.

The authors deserve the highest praise for their conception, enthusiasm, care, and toil to bring this guide to completion, as does the publisher for the suburb quality of the production. It is the new benchmark for other provinces to try and match.

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Mammals of Australia

By J. Turner. 2004. Pensoft Publishers. Acad. G. Bonchev Str., Bl. 6, 1113 Sofia, Bulgaria. 216 pages. Eur 38.50 Cloth.

Having a particular interest in camels at this time, the first thing I tried was to look up this species. The book is arranged alphabetically by common name. So I tried "Camel" without success. Next I looked under D for "Dromedary", also without success. By going through page by page I found "One-humped Camel" under O. Under this system I noted that House Mouse and Humpbacked Whale shared a page – an odd com-

bination! The index is arranged in exactly the same way so is no help and is superfluous. This was not an impressive start. There is a "Quick Index" arranged in taxonomic order that is helpful if you know the scientific names and sequence of mammalian orders.

The information on the One-humped Camel (and the House Mouse, Humpbacked Whale etc.) was clear, meaningful and concise. Camels are now wild in Australia and these feral residents probably represent the most "natural" population in the world today. Certainly they seem to be extinct in their land of origin (America) and their classical home in North Africa-Arabia.

This arrangement by common name renders it difficult to make comparisons. The common kangaroos are under E, W and R (Eastern Grey Kangaroo, Western Grey Kangaroo and Red Kangaroo) You have to flip between widely separated pages to find the differences in morphology and range. There are places where you could see all three species in the same location (such as Northwestern New South Wales.) and a direct evaluation would be useful.

The range maps are a little confusing. A typical map shows the range in blue. Other maps are coloured light green. At first I thought this colour was used to show the range of the extinct species shown in the book. Later this was less clear as it was also used for subspecies and endangered species. I searched for an explanation of the range maps but did not find one. One curiosity I noted with the range maps is that only three creatures are continent-wide – the Echidna and two introduced species, the Cat and House Mouse. (Five others are almost continent-wide, Common Walleroo, Gould's Wattled Bat, Red Kangaroo, Rabbit and Dingo) Many of the rest are quite localized.

The illustrations are odd. Eventually I realized they reminded me of children's tracings. The shape is mostly correct but gets smoothed out in places. The Red Fox is an odd looking creature. The accuracy of the colours varies. For example the Mountain Possum is grey not brown, but I think the pointed tail make the identification clear. The Greater gilder is depicted as grey-headed and white-tailed when it can be the reverse. The text somewhat clarifies this distinction. The oddest colour rendering of all is the silvery grey Antarctic Fur Seal. All those I have seen are rich brown. However, some of the illustrations are quite good. The Leadbeater's Opossum , the Agile Wallaby and the Banded Hare Wallaby all seem to be fairly accurate.

Despite my criticisms I do not think anyone will have a problem identifying a mammal though. Using the text, range map and the illustration should enable you to reach a clear conclusion on any of the 319 species covered. (This is a little short of the accepted total of 379 and I think those missing are some bats and marsupials, plus most of the cetaceans.) So, as there is sufficient diversity and differences in range you can still use this book as a field guide. The size (21 × 28.5 cm or 8.25 × 11 in.), however, means it is not truly portable.

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Birds of the Raincoast: Habitats and Habitat

By H. Thommasen and K. Hutchings, with R. W. Campbell and M. Hume. 2004. Habour Publishing, PO Box 219, Madeira Park, British Columbia, V0N 2H0 222 pages, Can $44.95.

This nice book describes in very delightful terms some components of the great Canadian biodiversity heritage: birds of the fascinating raincoast. It offers more than simply a nice coffee table book of a unique location and its fauna. Instead, this book consists indeed of a very sophisticated and well-written text covering all relevant aspects about birds, including species descriptions at given habitats in the stunning Canadian province of British Columbia.

The text and the brilliant photos are presented by four writers and nine photographers. The nine chapters deal with birds across seasons in the various and complex habitat types of B.C.'s raincoast (south and central coast, but not its islands).

This book is written by some of the bird and photo experts in the province. It cannot be denied that the traditional Anglophone, if not English, culture dominates in this book, as this culture also somewhat dominates the B.C. bird scene. No wonder, the first author is a country doctor, the second author makes a living in an English Department.

The bird photos are among the best I have ever seen for B.C. Some readers might find bird photos taken at the nest old-fashioned, and in some circles they deemed to be unethical even (since disturbing birds on nests and thus not publishable).

The photo layout and arrangement of the text strikes a great balance between detail and text flow; for the bird enthusiast this book is simply a joy to read and to browse through. Popular bird names are explained, and the poetry literature link is made by citing Anglophone poets from U.S., Canada and UK, such as Archibald Langman, William Blake, John Burroughs, Duncan Campbell Scott, John Clare and others. Personally, I specifically like the raptor, owl and sparrow sections, and the photos of the wood-warblers, blackbirds, owls, flowers and plants.

The wording in this book is extremely careful. However, I do not agree with the statement made by the authors that long-distance migration is a risky business for birds. Some species actually living that life-style have the longest life span known for birds; e.g., Terns and Godwits.

Allowing for a more global context, I really like that wintering grounds for B.C. birds are named as well,

which can wander off to Nicaragua and other tropical locations. However, some more spatially explicit information would be helpful for people exploring B.C. and its birds, too; e.g., a map and location names where bird species can be found in B.C. The authors clearly must know these details but so far don't share them with the reader.

Hardcore birders might be happy to learn that the book addresses how to avoid confusing Mallards from Shoveler, but no distinguishing field photos are shown really for identification headaches such as Common and Barrow goldeneyes, the species of mergansers, loons, grebes and crows. Issues of rare birds are basically ignored. So one will not learn about Eurasian stragglers from Russia that excite the B.C. birding community much and which increase birding tick lists. Avian subspecies do not get covered in depth, but some avian genetic issues are addressed.

Fascinating details on birds in B.C. get shared: The first Barred Owls were seen on the B.C. coast in 1966. The re-use of nests from owls and cavities by other birds are explained, the reader learns what "Sap Wells" are, and what makes for dabbling and diving ducks. Winter survival strategies are explained, the concept of Nest-Helpers is introduced, as well as the odd behavior that Rosy-finches cover the nest with their wings. I also like the mentioning of (sea) mammals, and how glaciation provides the reason that Myrtle and Audubon warblers, two waxwing species, and Red- and Yellow-shafted flickers can be found in this huge province, which is at least two times larger than California. The authors mention that some people in B.C. perceive birds as pests; e.g., Golden-crowned Sparrows. The Bird Checklist and the Index are nice additions making this book a well structured resource.

The authors cite John Clare: "To study birds without reference to their habitats is to examine their carcasses in glass cases". And here I find the book a little weak. Major issues for B.C., and which every bird enthusiast will notice in no time during an outdoors trip, such as habitat loss, pollution, urbanization and boating and their excessive human foot prints, etc. are not sufficiently mentioned when considering its magnitude and importance for B.C. Environmental buzz words such as clearcuts, fragmentation, oil spills or even Clayoquot Sound and Carmanah Valley do not really exist, nor is there a mention of Fraser River, or Queen Charlotte Islands and pelagic habitats. At least it gets mentioned that Glaucous-winged Gulls have increased three times in B.C. during the last 50 years (no reasons given), and that many river populations of Euchalon have been lost. Changes in Cormorant and Raven numbers and other related information are not mentioned.

This book might not fully satisfy readers that have a strong science hunger: Scientific names are not presented, researchers are rarely named (except for Margaret Nice and her Song Sparrow work) and this books lacks quantitative statements, other than a given home range of the Pileated Woodpecker (1000 acres) and that the Brown-headed Cowbird population would run up to 50 million individuals. Initially, I found that the authors overemphasize a little that birds would be monogamous, but the Extra-pair Copulation (EPC) issue gets mentioned in the text later. I cannot agree with the impression somewhat portrayed in the book that feeding birds in winter would do any good to them, and that birds would not survive otherwise. Birds actually evolved fairly well without bird feeders and did well without any human intervention over the last hundred thousands of years.

If one wants to be really picky, one can have a little seabird issue with this book though. Short-tailed Albatross, Cassins Auklets and Tufted Puffins are not mentioned. The massive Old-growth Forest habitat loss relevant for Marbled Murrelets get only mentioned marginally. I am quite sure that the 8500 figure, presented by the authors as the total British Columbia breeding population for Marbled Murrelets is a drastic underestimate. The latest overall population estimate for B.C. is 60000 and some models suggest even over 150 000 birds (this includes non-nesting birds). There is no Marbled Murrelet nest photo presented; a key icon for how birds can serve as habitat indicators for the raincoast. The Bird Checklist is nice but does not fully match my experience: Marbled Murrelets for instance are not rare, but can in some fjords and during winter be among the most abundant species in coastal waters even (as for instance the case in Clayoquot and Desolation Sound). Despite all this great detail, existing expert knowledge of the authors and a wonderfully detailed text, I am not clear why the first Canadian Marbled Murrelet nest found in 1992 by Volker Bahn and others is not mentioned (but the first one found 1974 in California gets presented).

One point that puzzles me, and which might explain some issues I would summarize from above as being "uncritical" or "unaware" about environmental raincoast issues in B.C., is a phrase in the acknowledgments: "Weyerhaeuser and BC Hydro served as a source of inspiration and researching this book". Most environmentalists and bird enthusiasts actually might not relate these major companies with inspiration, nor perceive them as a great guide for research.

Despite its potentially huge value, I am also puzzled by a text feature presented in the appendix dealing with "Proactive Conservation in British Columbia: The Wildlife Data Center". In recent years, much of British Columbia's conservation has been severely affected, if not harmed, by the lack of free and shared high quality data among experts and agencies. The professional conservation climate in British Columbia is actually quite "polluted" due to this situation. Taken from its description, this data center holds much of the urgently needed information which is so crucial to sustainable and progressive land and habitat management and conservation of wildlife and birds in the province. Despite its claim to be pro-active no website is presented to the audience. I miss the word "digital" in there, too.

Here is where the cultures and generations truly clash. And how does this relate, link and compare with what the Canadian and provincial government does (see for instance Geogratis website http://geogratis.cgdi.gc.ca/)? Here a change and update to the new millennium is needed for British Columbia so that high quality bird and conservation data are freely shared and made available to the global public over the internet nowadays. The description of the data center mentions for instance that they hold the largest nest record data pool for Canada with 180 000 records! Let's put these massive data sets on the public table for much of the urgently needed Conservation Management in British Columbia.

The book jacket reads: "Perfect for Birdwatchers, Naturalists and Environmentalists."

The reader might decide him- or herself on the philosophical question how much birds can and should be used to address environmental concerns, and whether they contribute to conservation. I recommend this book for sure as a very nicely written description and photographic explanation of birds in British Columbia, as well as a celebration of a Canadian and world heritage component.

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The Bird Almanac: A Guide to Essential Facts and Figures of the World's Birds

By David M. Bird. 2004. Key Porter Books Ltd. 6 Adelaide Street 10th Floor, Toronto, Ontario, M5C 1H6. 460 pages, Can $24.95 Paper.

Within this book is a massive amount of bird-related information! This review could actually end right here. However, I will elaborate somewhat.

Information in this book is presented in three ways: line drawings (restricted to the anatomy chapter), tables/lists as well as glossary-style entries. These are all appropriate and lead the reader to finding information rather quickly. There is both *birding* information and *ornithological* information (and a massive amount of overlap which is shared by both). A glossary of over 20 pages contains over 1000 terms – surely the word you're looking for must be there!

There are simply too many categories of information to give more than a smattering of examples here. Both traditional and genetically-based classifications of bird families are given, followed by the massive list of all known bird species. Significant people are listed in several tables, ornithological award recipients, world-class listers, Taverner Cup winners, bird artists and more. Bird watching clubs, ornithological societies, magazines and journals are listed from sources around the planet.

To compare this book with Leahy's *The Birdwatcher's Companion*, a recent tome of similar intent, would be to have *The Bird Almanac* come on top. The former is essentially all in dictionary format, and therefore lacks the comparative ease (or the ease of comparisons) of the thematically-organized, tabular format in *Almanac*. There are more in-depth definitions and descriptions in *Companion* (it is also a much bigger book), and the bibliography is better- organized, but I believe birders will much more *enjoy* flipping through *Almanac*.

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Common Birds of Ontario

By J. Duane Sept. 2004. Calypso Publishing, P.O. Box 1141, Sechelt, British Columbia, V0N 3A0. 94 pages, Can. $12.95 Paper.

This slim volume is an entry in the "common birds to know" category. It presents some 142 species, mostly two per page, each with a small coloured photograph of the bird, together with a brief description, some information on size, nesting and habitat, followed by a paragraph or two on some topic of more general interest. A few accounts include a "Similar Species" category, and about 10% of the species receive a full-page treatment with two pictures.

There's a role for well-thought-out books of this kind. Persons who are mildly interested in birds, but who are not ready for a comprehensive guide, might skim through the pages of a book of this kind, and try to match up the bird they had just seen with one of the illustrations. But to be really useful, the author must give careful thought to the selection of species and to utilizing the limited space to the best advantage, recognizing the user will likely be a complete novice.

Unfortunately, the present volume does not meet these objectives; in fact, I was left with the feeling that the author himself does not know Ontario birds very well. Problems abound, and there is only space here for a brief sampling. The selection of species is puzzling: avocet and Wilson's Phalarope are in but Mute Swan, Eastern Phoebe and grackle are missing. Lesser Scaup appears but Greater is not mentioned; Tennessee and Cape May warblers are shown but Magnolia and Black-and-white are not.

Some plate selections are poor: for example, the Red-tailed Hawk appears to be of the western race and could confuse a beginner; and the Least Flycatcher's wingbars are almost wholly concealed. The text is also misleading in places. We're told wigeon are "often" found wintering in large flocks on golf courses, Long-tailed Duck is a "common migrant", but "not often seen in large num-

bers", Gray Jays are widespread and Wilson's Warblers are "common in moist areas". The foregoing are just a few examples of inaccuracies which could have been readily avoided, and which are bound to mislead the potential reader. All in all, this is not a book I can recommend.

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Frogs of Australia: An Introduction to Their Classification, Biology and Distribution

By James R. Turner. 2004, Pensoft, Sofia-Moscow. 163 pages. Price not available.

Australia is renowned for its mammals, unique as a consequence of that continent's long separation from the other land masses. Of the amphibians, only frogs are represented; both the caecilians of other southern continents and the salamanders characteristic of northern continents, are absent.

Frogs of Australia presents 218 forms (213 species, one divided into 5 subspecies and one into 2); 110 of these named since 1960. The five families represented contain 29 genera. Three families are held in common with Canada. Hylidae occurs in the Americas, Europe, Asia and northern Africa but its 76 Australia species are often separated as the Pelodryadidae). Bufonidae is represented only by the Cane Toad, *Bufo marinus*, introduced from Hawaii in 1935 which, despite its near legendary reputation for decimating the native Australian frog and small mammal fauna, has spread only in the eastern edge of the continent, occurring in the Northern Territory, Queensland, and New South Wales. Ranidae, of the Americas, Eurasia and Africa, occurs only marginally with a single species only in the Cape York Peninsula in the northeast. Surprisingly, the latter resembles our Canadian Wood Frog, *Rana sylvatica*, in pattern (dark mask) and call ("like the sound of a duck but lacks a musical quality"). Of the other three families, two are not represented in Canada: the Myobatrachidae 118 species (formerly included in the southern western hemisphere Leptobatrachidae) and Microhylidae 18 species (widely distributed in southern western hemisphere, Africa and Asia).

Most forms are given a vertical half page column, but six have two columns (two with consecutive half pages; four on one entire page each). A problem for the non-Australian (and perhaps even some Australians) is that the forms are sequenced in alphabetical order by English names, rather than being grouped by family or genus. Thus, in one case two subspecies with distinctive common names are separated by 100 pages. The only other subspecies fortunately have a base common name, each form with a modifier, so all five occur consecutively.

Every form is illustrated in colour and accompanied by a range map. The text accounts are very brief: Latin name, Synonyms, Family name, Habitat, Distribution, Length, Abundance, Status, Meaning (of Latin name), Behaviour (generally breeding and call), Development (number of eggs, where laid), and Locality (political divisions it occurs in). Although all are by the author, the illustrations vary from superb to less so, with those in which a bit of substrate is included more deftly done while the others give the effect of crude cutouts. But as Dr. T. J. Hawkeswood points out in the Forward they "add a 19th century feel to the book". No variations are depicted. The maps apparently give a background of regional elevation in dark green, light green and tan though this seem not to be explained anywhere and the colours could be taken for vegetation zones. Superimposed, the purple depiction of range effectively stands out for all but the most restricted distributions. The superb layout facilities flipping through for an overall impression of variation and ranges.

Additional text is minimal. A Quick Find Index lists families and contained species by scientific name and page number of account, and an Introduction covers topics such as How Old Are Frogs (at least 180 million years), Common and Scientific names, Species and subspecies, descriptions, distribution. A page of diagrams depicts Diagnostic Characters of Frogs, four pages list the characters of the families and genera with comments on conservation. An outline map gives the eight political divisions and a two or three letter code for each (but West and South Australia are both designated WA whereas the latter is properly SA in the text). The book concludes with a two-page Glossary (address to xeric) a 20 pages of references and a three-page index to common and scientific names.

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Experimental Approaches to Conservation Biology

By Malcolm S. Gordon and Soraya M. Bartol. 2004. University of California Press. Berkley, California. xv + 343 pages, $75 US.

The papers collected together in this volume were originally prepared for a conference of the same name held in 2001. The editors have brought together research that emphasizes both basic and applied scientific experiments related to conservation, particularly those at the organism level.

The book consists of four sections. The first section, Introduction, consists merely of a five-page introduction along with a one-page list of conservation-related websites. The list of web resources is very basic and is limited to five government sites (one Canadian and four American) along with a number of major NGOs

such as the Nature Conservancy and World Wildlife Fund. Each of the remaining sections begins with an overview of the section and then papers on that topic. The second part of the book consists of seven papers on the theme of "Conservation of Endangered Species." The papers cover a variety of species (e.g., tree snails, rock iguanas, New Zealand birds, Australian marsupials) and topics (e.g., *ex situ* propagation, amphibian decline, conservation endocrinology). Section three, "Control or Elimination of Exotic and Intensive Species" features three papers on the subjects of California grasslands, tree invasions and the use of biological controls on exotic species. The final section of the book, "Policy-related Matters" contains four papers. Topics include the case study of the US Army and the Desert Tortoise and the challenge of biodiversity conservation within African national parks.

As is usually the case in such volumes, the papers vary substantially in their scope and quality. At one extreme, Michael Hadfield and collaborators provide an overview of the over 20 years of work his lab has done on the conservation of Hawaiian tree snails of the genus *Achatinella*. Their work has combined mark-recapture field studies, devising field exclosures to protect populations, developing protocols to maintain populations in the lab, and developing conservation priorities through the use of genetic markers. In contrast, other papers focus on a single issue or experiment. In addition, although all the papers were prepared for this book they vary in format, with only some of the papers including a summary. Nonetheless, this is a strong collection of papers, displaying the breadth of experimental conservation biology.

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Gulls of North America, Europe, and Asia

By Klaus Malling Olsen and Hans Larsson. 2004 $55.00 Cloth.

My reaction on opening this book was akin to the one I had when I first saw Seabirds[1] – this is a giant leap forward. It is a glorious wad of text accompanied color paintings (by Larsson), wonderful range maps and a multitude of color photographs. The authors say they cover forty-three species of gull. I found there are 50 species of gull worldwide that have generally been accepted in the recent literature. Of the 43 covered in this book 37 are on the world list. The remaining species are splits made and justified by the authors. These are Thayer's, American Herring. Caspian, Vega, Heuglin's and Common Gulls. Adding these in would bring the world total to 56. Also included are three South American vagrant species that are covered by a short text and a couple of photos. This means the book covers three-quarters of the world's gull species.

Each species is described in extensive detail, with a full description of all plumages at all life stages and racial variations. The accompanying illustrations support the text in these details. Additionally there are some comparison plates comparing similar species.

So this is a book of detail and it is in the detail we find the devil. Gull taxonomy is notoriously complex, poorly understood and subject to argument. I decided to examine first the Herring Gull and the newly-split American Herring Gull. Comparing the descriptions with the author's illustrations of the adult, I found it difficult to discern the majority of the "differences." I have noted similar bird-to-bird variations in single flocks of each one of these "species." I quickly realized I was concentrating on the photos and not the paintings, as I found the depictions too pale. The photos were closer to the pearl grey of my memory. There are comparison plates of large gull taxa (a good idea) where the American Herring Gull is shown as paler than an Iceland Gull. This is not an error as it is set in the middle of Glaucous and Glaucous-winged Gulls, and not with the European Herring and Yellow-legged Gulls.

The comparison of the non-adult plumages is even more difficult. Picking your way through the myriad of details of multiple plumages for each species is time consuming and can be tedious. This is not a criticism nor a question of right and wrong, but more the part of an ongoing debate. It has prompted me to look more carefully at the local American Herring Gulls this year.

Nowhere does this taxonomic debate emerge more clearly than with Thayer's Gull. The author notes "Taxonomic status not fully clarified." Many years ago I went through three trays of study skins at the Canadian Museum of Nature in Ottawa. The first tray contained Iceland gulls. The second contained Thayer's Gulls. The problem was the third tray had birds that looked like one of these species on their left side and the other species from the right side. In addition, during my years in Nova Scotia the commonest winter bird in my backyard was the Iceland Gull and I soon realized that it was a very variable species.

Next I turned my attention to the adult Great Black-backed Gull. This raised further questions. The text says "Legs flesh, sometimes with a grey or creamy (rarely yellow or extremely orange) ***tinge***." (my emphasis). Legs flesh, sometimes with a grey or creamy tinge certainly fits the birds I have seen. I have found a yellow-legged bird. The next species is the Kelp, also large and black-backed. The adult's feet are yellow but could be greyish-olive or greenish. When I, carefully (you do not want to damage the fine photos), curl the photos back so I can see the two birds side by side they are very similar, separated by their feet colour. If we had a grayish-footed Kelp Gull wander north would we notice it and would I get excited at a yellow footed Black-back? Yellow legs is the classic mark for separating the Lesser Black-back Gull.

Clearly identifying gulls is fraught with lots of pitfalls for the less than careful. Identification of vagrant gulls need to be done with vast care and all the field marks need to be examined. Likewise we should not pass off our local crowd of gulls as being the usual species; a great treasure could be hidden in the flock.

The pros and cons of gull taxonomy notwithstanding, this book is a wealth of information. The same exacting detail is given for all the species in the book, making it a treasure trove for the dedicated birder. Regardless of your opinion on the status of the species splits, there is much material for good scientific discussion and a basis for careful field observations. This all leads to the final question – why not go all the way and write Gulls of the World. After all it is only 13 more species, barring splits!

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The Monarch Butterfly: Biology and Conservation

By Karen S. Oberhauser and Michelle J. Solensky, Eds. 2004. Cornell University Press, New York. vii + 248 pages, illus. $39.95 US.

This book consists of a collection of scientific papers on the Monarch, divided into chapters on reproduction, migration and overwintering biology as well as some miscellaneous papers on general topics. Each of the four chapters is prefaced by a brief overview written by the editors. Karen Oberhauser is an Assistant Professor at the University of Minnesota, while Michelle Solensky is with the Department of Biology at the University of St. Thomas. The information presented includes observations from each of the three major Monarch populations worldwide (eastern and western North America and Australia).

This book contains a great deal of interesting information, presented as original scientific literature. The majority of the papers are well-written, although some are likely to be overly technical (especially in terms of the statistical analyses) for some readers. Of particular interest are the papers on citizen-based research programs, which present data collected by widespread networks of volunteers. These papers demonstrate how, with relatively modest training and logistical support, public participation can be used to enable research into wide-ranging populations which could otherwise prove difficult or impossible to monitor effectively. The overviews which introduce each of the four chapters help to make the information presented in the book more accessible to a broader audience (including, perhaps, some of the volunteers whose efforts are reported).

The black-and-white photographs which accompany each overview are excellent. However, the overall paucity of illustrations (other than the numerous graphs contained within the various papers) is regrettable. With such a colourful and attractive subject as the Monarch, surely it would not have been difficult to find more photographs to include in the book? Aside from their purely aesthetic value, additional photographs or drawings could have been used to enhance the text by illustrating some of the features, behaviours and methodologies described (e.g., growth and development, wing damage caused by courtship, experimental equipment design, etc.).

In short, this book presents interesting data on every major aspect of Monarch biology, with additional emphasis on the need to extend and incorporate such data into ongoing and future conservation efforts. However, the scientific format of the text may deter some readers, which is unfortunate considering the widespread public interest (as acknowledged in the book) in this familiar and beloved butterfly species.

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The Behavior and Ecology of Pacific Salmon and Trout

By Thomas P. Quinn. 2005. American Fisheries Society in Association with the University of British Columbia Press, Vancouver, Canada. 378 pages, illus. Cloth CDN $85.00; paper CDN $44.95.

The vast amount of literature on the Pacific salmon is rather intimidating. Indeed, several years ago when I first began conducting research on this group of fish after leaving the Midwest, it was difficult to know where to begin. Today there is a clear starting point I would read *The Behavior and Ecology of Pacific Salmon and Trout* by Thomas Quinn. This book is an excellent resource for students and fisheries scientists, providing a broad overview of Pacific salmon ecology. However, this book also has broader appeal to animal ecologists and naturalists. Thomas Quinn is a prominent ecologist (Professor at the University of Washington) who has devoted his career to research on Pacific salmon. He shares his passion and experience in the first comprehensive book to focus on the ecology and behaviour of the Pacific salmon. This book is complimentary to other compilations on this group of fishes such as the *Physiological Ecology of Pacific Salmon* by Groot, Margolis, and Clarke.

The book is focused on the salmon and trout in the Genus *Oncorhynchus*. This multi-species approach is one that could easily lead to confusion. However, Quinn

has provided the necessary context and background on basic life-history/natural history so readers, even if unfamiliar with Pacific salmon, will be able to follow. In fact, throughout the book he contrasts and compares interesting characteristics among species (and among populations) to reveal their incredible diversity. Quinn has also provided enough background on techniques in fisheries science that readers can gain an appreciation for the challenges in answering some questions. For example, in the migration chapter he discusses techniques for monitoring individual behaviour (e.g., conventional tagging, acoustic telemetry). For most trained fisheries scientists, some of the background material will be superfluous. However, it is necessary considering the broad audience. In the end, I believe that even the most experienced fisheries scientists will find the writing style and content to be refreshing and not too simplistic.

The book includes coverage of some rather novel topics within the 19 chapters. For example, this is the first fish ecology book that I have encountered that includes a chapter on the ecology of dead fish. Several years ago such a chapter would have been rather short. However, the explosion of research in the past few years on the role of salmon carcasses in the environment, much of which has been conducted by Quinn and his associates, enables such a chapter to be developed. This chapter in particular will be of interest to more general ecologists and naturalists. The chapters associated with adult migration and reproduction (2 through 6) are also exceptionally strong coincident with the authors expertise in those areas. That said, there were no chapters that I would consider weak, with my preference for some perhaps reflecting my personal interests and biases.

The text is well referenced but not to the extent that one feels like they are wading through a scientific manuscript. Quinn provides ample detail on the studies he summarizes, but more importantly, he provides extensive commentary and interpretation. He also poses questions that will serve as a springboard for countless graduate student projects. This is what really separates this book from other works that are available. His syntheses draw together data from disparate studies, often using this information to develop original figures or conceptual diagrams. His goal was to "inform and excite" the reader – a goal that I would argue he has more than achieved. The chapters are not exhaustive in coverage. Instead, Quinn has focused on selecting examples that contribute to an overall understanding of Pacific salmon and are interesting. Although his intent was not to advocate (as he reveals in the preface), the last chapter did provide some interesting final thoughts. As "the" authority on Pacific salmon, I would have appreciated if Quinn had expanded these sections on the current status and prognosis of Pacific salmon. It was this section that I found particularly fascinating, but it left me desiring more.

The book is available in both hard and paperback form and is reasonably priced. The photograph on the cover is stunning (taken by the author). Other photographs and plates within the text are equally interesting and of high quality. Exceptional care has been taken in developing crisp and clear figures that have consistent formatting throughout (e.g., axis, font, symbols). The author has eliminated details of most statistical tests presented by other authors and urges readers to consult original sources. Brief summaries are provided at the end of each chapter and the book concludes with an extensive index. Collectively, these characteristics further elevate the value of this work and contribute to its flow and ease of reading.

There are few groups of fishes, or other animals for that matter, where one could develop a book such as this that would have appeal to anyone with an interest in animal ecology. The book is extremely engaging and will leave the reader with a desire to don a pair of waders and explore some of these topics first hand. I am confident that Quinn's book will become a well-read and well-cited contribution. Shortly this book will be found on the office shelves of most salmon biologists, but I suspect it will be equally common in the personal libraries of armchair naturalists, anglers, and others with broad interests in ecology.

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Venomous Reptiles of the Western Hemisphere

By Jonathan A. Campbell and William W. Lamar. 2 volumes. 2004. Comstock Publishing Associates, Cornell University Press, Ithaca, New York. 870 pages.

This is a second edition, revised and expanded, of the authors' *The Venomous Reptiles of Latin America* published in 1989. Added to the southern species covered in that book are those occurring in North America. The authors are from the University of Texas at Arlington and at Tyler, respectively. Additional contributors are Edmund D. Brodie III and Jr. Indiana University and Utah State University, Ronald L. Gutbertlet Jr. and Michael B. Harvey University of Texas at Tyler and East Tennesse State University, Robert Norris Stanford University Medical Center, David A. Warrell, Centre for Tropical Medicine, University of Oxford, and Vinicius Xavier da Silva Universidade de Sao Paulo.

Theirs is an accomplishment of monumental proportions in size and collation of information. It is of coffee table format and includes a staggering 1500 colour photographs, 135 of them pictures of snakebite effects about which the authors' relate that a the first edition reviewer termed them their "hideous picture album".

The species accounts begin with two lizards (the Gila Monster and the Mexican Beaded Lizard, genus *Heloderma*), the sole members of their family and the only venomous reptiles other than snakes in the world. Two families of snakes follow (Elapidae, including here the coral snakes and the sea snakes) and Viperidae (here represented by pitvipers) in 190 species accounts. Omitted are the few poisonous rear-fanged Colubridae. Volume 1 contains all species except the rattlesnakes, while Volume 2 covers the latter.

The species accounts lead with scientific name and original describer and date, reference to figure (drawing), map (with dots of collections and shading for the suggested range), and plates (colour photographs), synonymy, local names, English name, and etymology. For some species a quotation from an historical observation is added. Sections follow on distribution, habitat, description, similar species, and remarks (including described subspecies and relationships with other species).

As comprehensive as these accounts are, there are other topics covered. In volume 1, there is an Introduction, Regional Accounts and separate Keys to Canada and United States, Mexico and Central America, The Caribbean Islands, and South America. Volume 2 includes chapters on Venomous Snake Mimicry, The Evolution of New World Venomous Snakes, Venom Poisoning by North American Reptiles, and Snakebites in Central and South America: Epidemiology, Clinical Features Management. The volume has an 11-page Glossary, and a 116-page Literature Cited. A 28-page index is repeated to conclude each volume.

Canada has only three *Crotalus*: The Timber Rattlesnake *C. horridus* (Ontario, now extirpated), Prairie Rattlesnake *C. viridis* (Saskatchewan and Alberta), Pacific Rattlesnake *C. oreganus* (British Columbia) and one *Sistrurus*, the Massasauga *S. catenatus* (Ontario). Despite the through coverage elsewhere, the peripheral nature of their distributions here may account for the scant coverage of Canadian references the southern-based authors have included. Some relatively recent contributions by Pat Weatherhead formerly at Carleton University, Tony Russell at University of Calgary, and Pat Gregory at the University of Victoria and their many students are included. However, some citations for Canadian distributions are merely popularized accounts by non-Canadians such Curran's 1935 rattlesnake article in the American Museum's *Natural History* or Kozloff's 1976 book an animals of the Pacific northwest. Many are dated, the citation to the pioneering Canadian checklist by Logier and Toner is to the first (1955) edition rather than 1961 revision. Two references to Barbara Froom are to 1964 and 1967 articles or pamphlets whereas her 1972 book is omitted. The detailed distributional documentation in the Ontario Herpetofaunal Summary and the status reports of Committee on the Status of Endangered Species of Wildlife in Canada (COSEWIC), or the symposiums on the Massasauga and conservation promotional newsletter *Rattlesnake Tales* sponsored by the Metro Toronto Zoo are ignored, perhaps because they are not readily accessible in the mainstream literature.

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Whales and Dolphins of the World

By M. Simmonds. 2004. The MIT Press, Five Cambridge Centre, Cambridge Masachusetts 02142. 160 pages, U.S. $29.95 Cloth.

Coffee table books of cetaceans seem to be popular with authors, photographers and the buying public. Here is another fine example. I note my local library has three shelves of mammal books. Almost 20% are on whales and the other books cover the rest of the world's 5000 or so species of mammal, a testament to the popularity of cetaceans.

While this book does not cover **all** the world's species it does have photographs of over 50 per cent. As you would expect the photographs are remarkably good. All the common species (common that is in books) like Blue, Sperm Humpback, Minke are there. But so too are some of the less well known and photographed, such as the Boto and Pink River Dolphin. These latter animals are not so difficult to see but are stunningly hard to capture on film.

The first half of the book is devoted to basic information on whales, similar to that found in most volumes of this type. The second half has information on the threats faced by these animals and the conservation measures in place or necessary. I also has a very odd error. The author writes of the Basques from northern France. Any Basque will tell they always lived in the Pyrenees Mountains of northern Spain and southern France.

The author list 83 species of whales and dolphins; one short of the most current list. The missing species is North Pacific Right Whale (*Eubalaena japonica*), recently separated by Rosenbaum et al, based on DNA. [This counting does not include *Delphinus tropicalis* as this is likely a variant of *D. capensis* and not a separate 84th species]

Why should I buy this book? I can think of three reasons. Any good whale book is worth having, especially when it such fine photos. The latter half of the book contains new and up-to-date information of importance. The royalties from sales are going to the Whale and Dolphin Conservation Society, where the author is Director of Science at the aforementioned society.

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BOTANY

Atlas des Plantes Villages du Nanavik – Atlas of Plants of the Nunavik Villages

By Marcel Blondeau, Claude Roy and Alain Cuerrier. 2004. Editions Multi Mondes, 930, rue Pouliot, Sainte-Foy, Quebec G1V 3N9, Canada. xxvii + 610 pages. $42.75 (includes taxes and shipping).

This small book (5 × 7 × 1 ⅛ inches) contains 433 pages depicting absolutely beautiful flowering plants and lichens that can be found around the villages in Nunavik, that part of Quebec north of latitude 55°N. Included on each illustration page is a distribution map which depicts the towns around which each species was found in Nunavik, together with a square mark which indicates its wider range into Iqualuit, Labrador, Newfoundland, Mingan Island and Gaspé Peninsula.

The Preface, Table of Contents, How plants are used by the Nunavik Inuit, List of Vascular Plants, List of Invascular Plants and General Index are all provided in three languages: French, English and Inuit.

This book will be most interesting and useful to all visitors of the seventeen localities which were visited by the first author between 1983 and 1998 who made observations of the plants within a 10 km radius of each of the sites. It will also be very intriguing to anyone who has an opportunity to examine this beautiful book but never have an opportunity to visit the region.

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ENVIRONMENT

Boreal Forest of Canada and Russia

By W. O. Pruitt and L. M. Baskin. 2004. Pensoft Publishers, Sofia, Bulgaria.163 pages, Hardcover. $94.76 (Can.)

Pruitt and Baskin are founders and directors of field research stations set up in the boreal forest regions of their respective countries. This book is far narrower in focus than the title suggests, however, concentrating on descriptions of the two field stations, their history, an outline of the work done there, and some observations on the surrounding terrain and landscape. The underlying idea, though unstated except through the title, appears to be that these two small areas can be considered representative of the vast regions of boreal forest on the two continents. The bulk of the book, though, does not deal with the forest but concentrates on its inhabitants. The text contains extensive discussion of the wildlife (pages 54–157) in the areas surrounding these field stations, with most of the discussion concentrating on mammals, which are the principal research foci of both authors. It is written in a straight-forward narrative style, with few in-text citations, and is clearly aimed at the avocational naturalist or general reader.

Most of the book focuses on the Taiga Biological Station, founded by Pruitt, which has been in operation since 1973. The station is located northeast of Winnipeg, near the Manitoba-Ontario border. It has provided a base for many ecological and zoological studies through the years. The Station's web page (www.wilds.mb.ca/taiga/intro.html) lists sixty-three written items, of which ten are MSc dissertations. The station has been used as a base for undergraduate field courses, visits by naturalists clubs, studies by museum curators, and projects by researchers from other institutions. Thus outreach and education, both formal and informal, are prime reasons for the station's existence.

About a third of the text discusses the Kostroma Taiga Biological Station, located northeast of Moscow in the Volga River drainage basin, set up in 1977. From Baskin's account, it appears that this area has been much more impacted by human activity than the area around the Canadian field station. He describes how intensive logging, game hunting, and fur trapping was carried out in the region. Recently, scientific activity at the field station has concentrated on game management and the study of animal populations under severe hunting pressure. Baskin also recounts attempts to introduce bison and cattle to the forest, to take advantage of grazing not being used by other large mammals (pages 97 -103).

The majority of the text describes the wildlife of the two areas. Many of the animals (such as hares, wolves, bears, and moose) are common to both areas. Following a general survey of the wildlife and habitats, Baskin describes in more detail two species of birds and seven of mammals, mostly large mammals or fur-bearers. Pruitt contributes descriptions of thirteen mammals or groups of mammals, seven groups of birds, and a brief survey of amphibians, reptiles, and a few invertebrates. He devotes much attention to the ecology of Woodland Caribou (pages 109-116), which he describes "as the most endangered mammal in Canada today" (page 116), under pressure from fragmentation of and development in its habitat and with the potential for further shrinking of available habitat in response to climate change.

Both field stations have been in operation for about a quarter century, yielding long-term data for their research areas. Such data sets are rare in ecology. Pruitt notes that he had the opportunity to set up studies of landscape recovery when the area around the station was afflicted by especially massive fires in 1980. Here,

however, is where I had a major problem with this book. There are no maps of the field sites! I found this omission truly surprising. It is impossible for anyone unfamiliar with the area to follow Pruitt's discussion of the course of the fires through the region (pages 58-64). Similarly, Pruitt spends time describing six one acre study plots set up in the field area (pages 49-54). However, I found myself wondering how these are distributed on the landscape, how they relate to each other and other landscape features such as lakes and streams, and what the pattern of substrates might be. There is really not enough contextual information here to make this account intelligible. I had a similar problem with the discussion of the Russian field station.

It is interesting to compare and contrast the difficulties both research directors describe in the running of their respective stations. The institutional and administrative settings differ, but many of the problems are common to both. Pruitt deplores the depredations by forest companies and excoriates the provincial government for lack of support for conservation of the boreal landscape. He also makes an impassioned plea for the sustainable use of the boreal ecoregion, advancing "ecotourism" as a use that is both sustainable and likely in the long-term to generate support for conservation policies. Baskin laments the chaos following the breakup of the Soviet Union and describes the inroads unrestricted hunting, not for sport but for food and subsistence, made into the mammal populations around the field station. It is clear that both stations have struggled with uncertainty and under funding and have battled to keep going. It is a tribute to the people involved that these stations have been operational for as long as they have. From Pruitt's account, the spirit of camaraderie, companionship, and sense of community engendered in people who have worked at the field station is strong. Pruitt makes it clear that an attitude of "make do" rules at the Taiga Biological Station, with creative scrounging of materials and supplies from unlikely sources and a great deal of "sweat equity" contributed by students and volunteers. I expect that almost every researcher involved in a field-based science or natural history in Canada can only smile wryly in empathy.

The most striking aspect of this book is the presentation of the information. The account is given in two languages with the text arranged in parallel columns, English to the left and Russian to the right, with equivalent paragraphs lined up. This is an interesting approach, though I imagine that very few North American readers will be able to read both languages. Moreover, it makes the book twice as long as it needs to be and therefore probably increases its price. The book is well-produced, on high-quality glossy paper, with 78 photographs, 72 of which are in colour, and robust binding. However, the list price is outrageous for such a slender volume and, unfortunately, will probably severely limit its distribution.

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Democracy's Dilemma: Environment, Social Equity, and the Global Economy

By R Paehlke. 2004. MIT Press, Cambridge Massachusetts, 306 pages. U.S.$ 16.95 Paper

"Many have a sense that governments are increasingly out of control". This book tackles this complex topic. It is written by one of the leading environmental thinkers and deals with major issues of globalization. Simply by assessing the global state of Forests, Topsoil, Biodiversity, Fisheries, Groundwater and Fossil Fuel, it becomes immediately obvious that we are borrowing the assets from future generations. As Paehlke states, these depressive facts are a logic conclusion when acting under the paradigm of "externalizing internal costs", which is the result of a mis-lead economy promoted by the current view and definition of globalization. Here we get convincingly reminded about the significant political error made in the 90s that "unfettered" markets would be the only way to economic and all other forms of societal success.

The book is divided into eight chapters and subsections which convince that "the assumption that economic expansion will fill our lives with sunshine" is faulty. As examples from India and U.S. indicate, wealthier nations are not the healthier ones. Nicely, the book describes features of our current society: volunteer organizations and voting are in decline; political cynicism is all too normal due to the powerlessness of citizens.

Besides a nice overview and introduction of globalization issues, subsequent chapters deal with the media: the TV is at the heart of globalization, asking us permanently to consume and to be entertained. Paehlke presents how this media is controlled by corporations, and thus not delivering conflicting or alternative messages. Instead, it just focuses in a stereotypical way on natural disasters, accidents and arrests. Despite information technology, we are actually living in an age of "missing information": Electronic media systematically avoids intellectual content in favor of visuals. Further, it is shown in this important book that the public Post Service deteriorated to an advertising bombardment infrastructure fueled by international corporations. In the U.S. alone, seventeen billion catalogues (64 for every man, woman and child) are mailed each year! Paehlke demands instead that the right of participatory access should be more often open to non-commercial interests and that individuals should have the right to establish some autonomy from commercial messages and images.

One entire chapter deals with a 'Three-Bottom-Line Perspective' which eludes to the fact that "There has

not been any effective balancing of economic, social and environmental factors and interests". For instance, GATT deals in its 20000 pages with corporate and business rights, but none deal with society and environmental issues. Other book sections elaborate on how to measure global progress: This matters as national GDPs go up, while there are strong indications that we are actually on the way backwards. For instance, tuberculosis, a disease related to poverty and wiped out in earlier times, returned. In the year 2005 we are producing cloths to similar conditions as done in 1805. This books suggests alternatives to the narrow GDP metric such as an Ecosystem or Human Well-being Index; "Economic growth is a means, not the end".

Major social and democracy aspects are touched upon throughout this book. The author emphasizes that trade panels are empowered to overrule national environmental laws. Therefore, there is a strong need for them to be publicly accountable and elected. The reader will learn why the idea of a full-blown global government is flawed in principle: The challenge is to achieve global governance through the cooperation of effectively democratic national governments. Globalization has flaws, for instance widely traveled products simply cannot be sustainable due to the high travel costs. We are exporting systematically environmental problems from rich to poor countries! Whereas U.S. has a high employment rate, in some countries it is even illegal to form unions. "In Mexico wages are a fraction of what they are in Canada and the U.S., effective pollution controls are more or less non-existent, and taxes for public health and education have been reduced or abolished". Social costs of electronic capitalism are very real and not taken into account by those in business and government who make the relevant decisions.

Paehlke actually shows that there are enough environmental and other warning signs that the current life style cannot be maintained, nor extended to third world countries. I liked best the book sections that deal with global economies and the environment, and with related legal and policy issues. The CEC (Commission for Environmental Cooperation) in NAFTA is basically exposed as being powerless; CITES is widely ineffective and has NOT stopped poaching. ITTO (International Tropical Timber Organization) as well as the Biodiversity Convention have basically failed by not halting tropical forest loss. RAMSAR and the Bonn Convention on Migratory Species are unfortunately not referred to in this book but are known to be inefficient as well. International environmental laws suffer from enforcement and binding rules, whereas the economic counterparts always offer drastic punishments when any of their terms are violated.

NAFTA, WTO and GATT have policies that allow polluters to sue national and local governments for even attempting to protect the environment. IMF (International Montary Fund) deals only with narrow domestic economic interests. Paehlke gives us nice examples such as the large pier in Cozumel threatening the Paradiso Reef (CEC jurisdiction), or the infamous dolphin-tuna ruling where the U.S. Marine Mammal Protection Act violated GATT in Mexico and was ruled not to be valid outside of national jurisdiction. Another case is mentioned where the WTO is in conflict with sea turtles and instead puts trade first. At least the ISO has some environmental management standards, but then this organization is again administrated by the corporate industry themselves. Why are environmentalists not asked when it comes to taxation or annual budgets? Perhaps we need a tax on consumption and energy waste?

The Ironies of the Global Age are: Rising poverty in the face of an enormous surge in productive capacities, declining leisure time in the face of increasingly automated industrial production, and reversals in environmental protection in the face of advancing environmental knowledge and high levels of environmental concern. This book fully exposes this "Cult of Impotence", which now is so widely found in governments and responsible agencies in the world. Critical voices are not wanted, discriminated against. It is indeed true, as stated by the author, that major administrative concepts such as communism, failed due to ignoring environmental issues and by being undemocratic!

The reader gets presented with a balanced view though. For instance that Globalization has seen modest successes in regards to human rights, labor rights and the rights of women and children. Computer and WWW spread democracy. Thirdly, the California effect (an increase in economy results into an improved environmental standards; e.g., air) is shown.

This book deals with the substance of democracy, not with its hollow form. The 275 pages are full of fascinating bits and pieces: What's the meaning of the (working) life? We replaced tedious industrial work with tedious and pointless marketing and retail work spending a considerable percentage of today's employees who are devoted to the task of selling us things we do not otherwise even imagine we need. Exotic species problems as a direct function of Globalization. Of interest is also the statistic that during the last 50 years humans have used more resources than during the entire previous human civilization. It is fascinating to learn that one can hire 47 Philipinos for 1 French worker, or that 200 of the wealthiest individuals are as rich as 41% of the world population! Some readers might be surprised to learn that U.S. has replaced Japan when it comes to workload. Subsequently, divorce rates and family breakdowns are on a record high. I am really unclear why such a hard working nation has the highest energy consumption though.

Besides fascinating facts, I also like the conclusions brought forward by Paehlke: Other authors described Globalization already as the "environmental race to the bottom". It is referred to as "laissez faire" capitalism. History shows that "laissez faire" cannot easily be reformed: It needed the disasters of the Great Depression and of World War 2 to shake the hold of an earlier version of the free market orthodoxies on western govern-

ments and societies. Nowadays, Global Change and Poverty are probably the single biggest failures of the free market system.

In this book, I found no major shortcoming (other than that Germany does not have a 48h working week, modern Russia and China get hardly mentioned, and the book index is incomplete), but some of the thoughts presented by the author could be challenged. It is correct that all natural commodities (mining, forestry, agriculture and fish products) but oil are going down in value. However, likely these commodities just loose due to the dominance, and convenience brought by, oil. Unfortunately, despite its catching and fascinating subject, this text makes for a hard and long read: I find it unnecessarily boring and repetitive.

In conclusion, we lack a global citizen movement. The reader of this book will whole heartedly agree that globalization also requires the definition of minimum standards for welfare, environment, taxation and wages. We are left with the need for crucial reforms: (i) we need a media reform, (ii) a social science reform away from "economics only", (iii) a radical election campaign finance reform, (iv) progress in the reduction of total work time with families at least to the level that was normal prior to the decline in civic participation, (v) and an appreciation of the need for global governance rooted in restored democracy at the level of the nation-state. I recommend reading this book and getting into action.

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Emulating Natural Forest Landscape Disturbances: Concepts and Applications

Edited by Ajith H. Perera, Lisa J. Buse, and Michael G. Weber. 2004. Columbia University Press, New York. 315 pages.

Disturbance is ubiquitous in forest ecosystems. Disturbed by the extremes of either catastrophic, stand-replacing events including fire, insect herbivory and extensive wind throw, or periodic, small-scale gap processes mediated by fungal pathogens, forests are in constant flux when viewed from a long-term, landscape perspective. A wide range in the periodicity, intensity and scale of disturbance events, and in the diversity of bio-edaphic interactions creates a complex, fluid, heterogeneous forest landscape.

Practitioners of sustainable forest management have accepted the essential links among natural disturbances, forest and stand structural heterogeneity and organism biodiversity. Recognition of these links has generated the conceptual and empirical development of a natural disturbance-based forest management defined as "an approach in which forest managers develop and apply specific management strategies and practices, at appropriate spatial and temporal scales, with the goal of producing forest ecosystems as structurally and functionally similar as possible to the ecosystems that would result from natural disturbances, and that incorporate the spatial, temporal, and random variability intrinsic to natural systems." (page 4)

Widely accepted is the assumption is that forest biological, structural and functional diversity developed within the boundaries defined by natural disturbances. As such, human interventions, such as logging or the use of prescribed fire, that conform "more or less" to the temporal and spatial dimensions of natural, historic disturbances are deemed to be those most successful in conserving biological diversity.

The book's editors include a forest landscape ecologist (Perera) and a forest biologist (Buse), both from the Ontario Forest Research Institute, and a fire ecologist (Weber) from the Great Lakes Forestry Centre of the Canadian Forest Service. Together they have produced a significant volume with contributions from both practitioners and academics who are actively engaged in the development of natural disturbance-based forestry.

The collection of essays is broken down into three main sections. The first section deals with the theoretical and conceptual foundations of emulating natural disturbance in forest management. The authors of the five essays in this first section do a commendable job of describing the ecological foundations and biodiversity implications of emulating natural disturbance in forest management. The eight contributors to the second section treat a host of case studies from different forest ecosystems throughout the United States and Canada. With the help of computer simulation models, historic natural disturbance regimes are assessed for use in disturbance-based forest management. These empirically-based technical studies are site- and computer-model specific and provide state of the art concrete applications of natural disturbance-based forestry. A 16-page suite of computer-generated full-colour maps provides examples of output from the various simulation models. The final section composed of seven chapters addresses the actual feasibility and practice of emulating natural disturbance through forest stand-based management. Industry and environmental non-governmental perspectives are also treated in this final section. The final chapter is an excellent synthesis of the current state of knowledge about emulating natural disturbance in northern North American forests.

Palaeoecological and historical evidence reveal that many forest ecosystems are shaped by the interaction of climate change, natural disturbances and human activities. The emulation of natural disturbance, therefore, can be akin to shooting at a constantly moving target. This book does not present emulation of natural disturbance as a forest management panacea. Nor does one

get a sense that forest managers must slavishly follow natural patterns and processes. Emulation of natural disturbance provides a sensible guide to sustainable forest management. It cannot, however, be carved in stone. The dynamic nature of forests, the existence of multiple successional pathways in response to disturbance and the even more dynamic needs and values of human societies would prevent that. The last lines of the book say as much: "Over the long term, the ultimate success of the approach will be determined by the answers to the questions of whether it is ecologically superior to other forest management paradigms, economically feasible for forestry practitioners, and socially acceptable." (page 274)

The editors consider the book well suited to all forestry professionals including practitioners, policy makers and researchers. To this list I would add conservation biologists, environmentalists and even environmental philosophers. The book deals not only with the conceptual and practical considerations of the emulation of natural disturbance, but helps to raise broader questions about biodiversity conservation in dynamic forests subject to both natural and human-induced change. This book should stimulate those philosophical questions, but you will have to resort to other works for the beginnings of a response.

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MISCELLANEOUS

The Nature Journal: A Handbook

By Frederick W. Schueler and Aleta Karstad. 2004. Bishops Mills Natural History Centre, RR 2, Oxford Station, Ontario K0G 1T0 and Little Ray's Reptile Zoo, 5305 Bank Street, Ottawa Ontario K1X 1H2 [www.thenaturejournal.ca]. $40.00

For any naturalist, whether professional or hobbyist, some form of notes are an essential reference to past observations. At one level they can serve for comparison with new observations or as reminders of where and when to look for certain species or seasonal phenomena. At another, they can be the basis for preparation of accurate published accounts. How to format and organize them for permanence and accessibility has more solutions than observers as even individual systems evolve over time. For those just starting to keep records or dissatisfied with previous efforts, Fred and Aleta Schueler offer a solution.

Since the 1960s, one or both have been observers and commentators of nature, collectors of biological specimens for museums, and writers and illustrators of both popular accounts and scientific papers. They have recorded their raw field data in a variety of journal and data formats. Here, they attempt to standardize this experience and outline a universal system that will produce notes not only of use to observers themselves but also serve as a permanent record of value for others. The Schueler's rightly regard leaving a useable record for future naturalists as a prime responsibility of us all.

What is outlined here is partly adapted from the once widely used system credited to Joseph Grinnell, Curator of the Museum of Vertebrate Zoology at Berkeley, California, in the first half of the 20th century. It also draws on field data entry sheets developed at the National Museum of Canada (now the Canadian Museum of Nature) in ichthyology and herpetology in the 1960s and 1970s.

A sturdy seven-ring binder is prefixed with 37 pages of instruction including: The role of archival naturalists, What needs study? What should I look for? What should I record? What if I do not know its name? Who is interested in what I observe? and explanation: The pages, Archival materials, Fine tuning accounts, Interpreting the datasheet, The Grinnell System: a brief history, Notes on journal-keeping, Acknowledgments, and Resources. An irritation is that an included reprinting of an unpublished report with three references has no documentation for these.

The *Nature Journal* contains acid-free archival paper of 50% cotton (Ernscliffe Linen Bond): 30 lined journal pages, 15 pocket pages, 15 "catalog" pages, 15 species account pages, 15 datasheets, 30 blank pages for drawings, 2 heavy acid-free pages for watercolour or labels, 4 acid-free separators. Also included is one archival ink "Pigma" felt tip pen and a ruled plastic page finder. An enthusiastic field-naturalist would soon use up the initial stock but additional pages are available from the authors.

In promised progress is an electronic data base for field notes. Although, as is pointed out here, this is far easier to search later but can be more time-consuming than written notes. The web address www.thenaturejournal.ca will provide updates.

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NEW TITLES

†Available for review *
Assigned for review

Zoology

Evolution of Amphibian Skull. Advances in Amphibian Research, Volume 9. By N. Lebedkina. 2005. Pensoft Publishers, Sofia 1113, BULGARIA, Acad. G. Bonchev str. bl.6. In English, 265 pages. URO 44.50 Paper. (Surface mail delivery: URO 5. Airmail delivery overseas: URO 15.)

***The Birds of Azerbaijan.** M. Patrikeev, 2004. Pensoft Publishers, Sofia-Moscow. 380 pages. URO 68.80 – Surface mail delivery: URO 5. Airmail delivery overseas: URO 19.

A Field Guide to the Caterpillars. By T. Allen, J. Brock, and J. Glassberg. 2005. Oxford University Press, 70 Wynford Drive, Don Mills, Ontario, M3C 1J9. 224 pages. Can $34.95.

Drawing Birds. By J. Busby. 2005. Timber Press, 133 SW 2nd Avenue, Suite 450, Portland, Oregon, USA. 144 pages, Paperback, U.S.$19.95.

Hunting for Frogs on Elston, and Other Tales from Field & Street. By Jerry Sullivan, *Edited by* Victor M. Cassidy. 2004. University of Chicago Press, 5801 Ellis Avenue, Chicago, Illinois 60637 USA. 320 pages. U.S.$25.00 cloth.

The Origin and Evolution of Mammals. By T. S. Kemp. 2004. Oxford University Press, 70 Wynford Drive, Don Mills, Ontario, M3C 1J9. 342 pages. £80.00 cloth.

Noncooperative Breeding in the California Scrub Jay. By W. Carmen. 2004. Cooper Ornithological Society. 100 pages. U.S.$15 Paper.

†Pronghorn: Ecology and Management. By B. O'Gara and J. Yoakum. 2004. University Press of Colorado, 5589 Arapahoe Road, Suite 206C, Boulder, Colorado 80303 USA. 904 pages. U.S.$85. Cloth.

Shorebirds of North America – the photographic guide. By Dennis Paulson. 2005. Princeton University Press, 41 William Street, Princeton, New Jersey 08540 USA. 384 pages. U.S.$29.95 paper, $65 cloth.

***Waterfowl of Eastern North America.** By Chris Earley. 2005. Firefly Books, 66 Leek Crescent, Richmond Hill, Ontario, L4B 1H1. 158 pages. $19.95 paper $29.95 Cloth.

White as a Ghost – Winter Ticks and Moose. By Bill Samuel. 2004. Federation of Alberta Naturalists, 11759 Groat Rd., Edmonton, Alberta T5M 3K8. 99 pages. Can. $24.95.

Wheatears of the Palearctic. Ecology, Behaviour and Evolution of the Genus *Oenanthe*. By E. Panov, 2005. Pensoft Publishers, Sofia-Moscow, 439 pages. Cloth URO 58.80 – Surface mail delivery URO 7. Airmail delivery overseas URO 14.

Botany

California's Wild Gardens – A Guide to Favorite Botanical Sites. *Edited by* Phyllis M. Faber University of California Press, 2120 Berkeley Way, Berkeley, California 94704-1012 USA. 248 pages. U.S.$34.95.

***An Illustrated Guide to the Eastern Woodland Wildflowers and Trees.** By M. Choukas-Bradley. 2004. University of Virginia Press, P.O. Box 400318, Charlottesville, Virginia 22904-4318 USA. 424 pages. U.S.$39.85. Cloth.

Other

Curious by Nature. By Candace Savage. May 2005. Greystone Books, #201 – 2323 Quebec Street, Vancouver, British Columbia, V5T 4S7. 160 pages, $22.95 Can. Paper.

† The Charting of an Atmospheric Environment. By M. Hamilton. 2004. Vantage Press Inc., 419 Park Avenue South, New York, New York 10016 USA. 262 pages, U.S.$24.95.

***The Earth's Blanket – Traditional Teachings for Sustainable Living.** By N. Turner. 2005. Douglas & McIntyre Publishing Group Suite 500, 720 Bathurst Street, Toronto, Ontario M5S 2R4. 304 pages, U.S.$29.95 Cloth.

Ecological Methods in Forest Pest Management. By David Wainhouse. 2004. Oxford University Press, 70 Wynford Drive, Don Mills, Ontario M3C 1J9. 248 pages, £55.00 Cloth.

Geoffroy Saint-Hilaire: A Visionary Naturalist. By Herve Le Guyader, Translated by Marjorie Grene. 2003 University of Chicago Press, 801 Ellis Avenue, Chicago, Illinois, 60637 USA. 288 pages, U.S. $45.00 Cloth.

Atlas of Pacific Salmon – The First Map-Based Status Assessment of Salmon in the North Pacific. By Xanthippe Augerot. 2005. University of California Press, 2120 Berkeley Way, Berkeley, California 94704-1012 USA. 161 pages, U.S.$34.95.

Preserving the Living Past – John C. Merriam's Legacy in the State and National Parks. By Stephen R. Mark University of California Press, 2120 Berkeley Way, Berkeley, California 94704-1012 USA. 219 pages. U.S.$39.95.

Record of Documents, 1964 – 2004, Pertaining to the Preservation of Kamoka Park, ON with a biography of Osmund Langvet (1926 – 1979). By W. Judd. Phelps Publishing Company London, Ontario.

Catalogue of Meetings 1988-2004 of the Birding Wing of the McIlwraith Field Naturalists of London ON. By W. Judd. Phelps Publishing Company London, Ontario.

Children's Books

The Kids' Guide to Zoo Animals. By Michelle Gilders. 2004. Red Deer Press, Trailer C, 2500 University Drive, Calgary Alberta, T2N 1N4 Canada. 264 pages, cloth, $16.95 Can.

News and Comment

Marine Turtle Newsletter (107)

January 2005. 28 pages: ARTICLES: Morphometric Analysis of the Northern Subpopulation of *Caretta caretta* in South Carolina, USA — Marine Turtle Conservation in Viet Nam — Towards 2010 — NOTES: Holding a Live Leatherback Turtle in Israel: Lessons Learned — The Marine Turtles of Hinatuan Bay, Surigao del Sur, Mindanao, Philippines — Two Records of Live Olive Ridleys from Central California, USA — Oceanic Habitats for Loggerhead Turtles in the Mediterranean Sea — Sea Turtle Nesting Sites at Lian, Batangas, Philippines — New Records on the Distribution of Loggerhead Turtles (*Caretta caretta*) in the Philippines — Stranded Sea Turtles on the Coast of Paraiba – Brazil — Underwater Oviposition by a Hawksbill Turtle in Guadeloupe, French West Indies — IUCNMTSG UPDATE — ANNOUNCEMENTS — NEWS & LEGAL BRIEFS — RECENT PUBLICATIONS.

The Marine Turtle Newsletter is edited by Brendan J. Godley and Annette C. Broderick, Marine Turtle Research Group, Centre for Ecology and Conservation, University of Exeter in Cornwall, Tremough Campus, Penryn TR10 9EZ United Kingdom; e-mail MTN@seaturtle.org; Fax +44 1392 263700. Subscriptions and donations towards the production of the MTN can be made online at <http://www.seaturtle.org/mtn/> or postal mail to Michael Coyne (online Editor) Marine Turtle Newsletter, 1 Southampton Place, Durham, North Carolina 27705 USA (e-mail: mcoyne@seaturtle.org).

Froglog: Newsletter of the Declining Amphibian Populations Task Force (67): Last Printed Issue

Number 67 February 2005. *Last Printed Issue* Contents: DAPTF Seed Grants 2005 — Action for the axolotl at Lake Xochimilco [Richard A. Griffiths and Ian G. Bride] — The Stutus of Great Crested Newt Breeding Sits in Serbia [Jelka Crnobrnja-Isailovic, Ivan Aleksic & Jan Willem Arntzen, DAPTF Seed Grant Recipients — Meeting on disease and threats to amphibian biodiversity [James Collins] — Introduced fish, rotan *Percollus glenii* — an unavoidable threat for European amphibians [Andrey N. Reshetnikov] — Froglog Shorts: Due to escalating printing and shipping costs the printed copies of Froglog will no longer be be generally distributed. The newsletter *Froglog* will continue, posssibly increasing in size and frequency, available free at http://www.open.ac.uk/daptf/froglog. It can also be accessed through Herp Digest's listserve at http://www.herpdigest.org/

Froglog is the bi-monthly newsletter of the Declining Amphibian Populations Task Force of The World Conservation Union (IUCN)/Species Survival Commission (SSC) and is supported by The Open University, The World Congress of Herpetology, and Arizona State University. It is edited by Jeanne McKay (65) and Jeanne McKay (66),, Department of Biological Sciences, The Open University, Walton Hall, Milton Keynes, MK7 6AA, United Kingdom; e-mail: daptf@open.ac.uk. Funding for *Froglog* is underwritten by the Detroit Zoological Institute, P. O. Box 39, Royal Oak, Michigan 48068-0039, USA. Publication is also supported by Peace Frogs www.peacefrogs.com and by RANA and the US National Science Foundation grants DEB-0130273.

New Canadian Journal: *Wildlife Afield* (1 and 2)

A new British Columbia semi-annual publication *Wildlife Afield* (ISSN 1712-2880) is to be issued by The Biodiversity Centre for Wildlife Studies twice a year.

Volume 1, Number 1, contains FROM THE EDITOR: *Wildlife Afield* – An introduction; On the covers — FEATURE ARTICLE: Food habits of the Barn Owl in the southern interior of British Columbia (Linda M. Van Damme and Mark Nyhof — NOTES: First occurrence of Wandering Salamander on the Sunshine Coast of British Columbia (Glenn R. Ryder and R. Wayne Campbell) — Dusky Flycatcher breeding in the Peace River Region of British Columbia (Doug Brown) — Upland Sandpiper breeding near Chetwynd, British Columbia (R. Wayne Campbell) — Occurrence of the Rock Wren on Vancouver Island and other islands in the Strait of Georgia (Michael I. Preston) — Unsuccessful introduction of the California Quail to the Queen Charlotte Islands (R. Wayne Campbell) — WILDLIFE DATA CENTRE: Featured species – Semiplamated Plover (R. Wayne Campbell) — Report of the Wildlife Data Centre: 1 June 2003 to 30 June 2004 (Michael I. Preston) — BRITISH COLUMBIA ROUND-UP: Field notes and caring people — News of Friends — From the Archives — Final Flight — Publications of Interest — Announcements and Meetings — Support for a Shared Vision — Your Data at Work — Biodiverstiy Centre for Wildlife Sudies: Our Logo.

Volume 1, Number 2, contains: FROM THE EDITOR: And the ship sets sail — On the covers — FEATURE ARTICLES: Temporary colonization of Cleland Island, British Columbia, by Common Murres from 1969-82 (Harry R. Carter) — Conservation priorities and peripheral species in the south Okanagan: Considerations for a proposed National Park (Joanna Preston) — Effectiveness of global protected areas? Perspectives for British Columbia (Michael I. Preston) — NOTES: Observations of breeding Dusky Flycatchers in the central Okanagan Valley, British Columbia (Chris Charlesworth) — Field observations of Bullfrog (*Rana catesbeina*) prey in British Columbia (R. Wayne Campbell and Glenn R. Ryder) — Gross bill deformity and longevity in a Northern Flicker (Sherry L. Lidstone) — Gray Wagtail (*Motacilla cinerea*): a new species for British Columbia (Jerry Etzkorn and Janet Etzkorn) — Lark Sparrow nesting in the Peace River region of British

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Advice for Contributors to *The Canadian Field-Naturalist*

Content

The Canadian Field-Naturalist is a medium for the publication of scientific papers by amateur and professional naturalists or field-biologists reporting observations and results of investigations in any field of natural history provided that they are original, significant, and relevant to Canada. All readers and other potential contributors are invited to submit for consideration their manuscripts meeting these criteria. The journal also publishes natural history news and comment items if judged by the Editor to be of interest to readers and subscribers, and book reviews. Please correspond with the Book Review Editor concerning suitability of manuscripts for this section. For further information consult: A Publication Policy for the Ottawa Field-Naturalists' Club, 1983. *The Canadian Field-Naturalist* 97(2): 231-234. Potential contributors who are neither members of *The Ottawa Field-Naturalists' Club* nor subscribers to *The Canadian Field-Naturalist* are encouraged to support the journal by becoming either members or subscribers.

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Please submit, **to the Editor,** in either English or French, **three** complete manuscripts **written in the journal style.** The research reported should be original. It is recommended that authors ask qualified persons to appraise the paper before it is submitted. All authors should have read and approved it. Institutional or contract approval for the publication of the data must have been obtained by the authors. Also authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants or minerals. The place where voucher specimens have been deposited, and their catalogue numbers, should be given. Latitude and longitude should be included for all individual localities where collections or observations have been made.

Print the manuscript on standard-size paper, **doublespace throughout,** leave generous margins to allow for copy marking, and **number each page.** For Articles and Notes provide a citation strip, an abstract and a list of key words. Generally, words should not be abbreviated but use SI symbols for units of measure. The names of authors of scientific names may be omitted except in taxonomic manuscripts or other papers involving nomenclatural problems. "Standard" common names (with initial letters capitalized) should be used at least once for all species of higher animals and plants; all should also be identified by scientific name.

The names of journals in the Literature Cited should be written out in full. Unpublished reports and web documents should not be cited here but placed in the text or in a separate Documents Cited section. List the captions for figures numbered in arabic numerals and typed together on a separate page. Present the tables each titled, numbered consecutively in arabic numerals, and placed on a separate page. Mark in the margin of the text the places for the figures and tables.

Check recent issues (particularly Literature Cited) for journal format. Either "British" or "American" spellings are acceptable in English but should be consistent within one manuscript. **The Oxford English Dictionary, Webster's New International Dictionary** and le **Grand Larousse Encyclopédique** are the authorities for spelling.

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FRANCIS R. COOK, Editor
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ISSN 0008-3550

The CANADIAN FIELD-NATURALIST

Published by THE OTTAWA FIELD-NATURALISTS' CLUB, Ottawa, Canada

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Volume 119, Number 2

April–June 2005

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The Canadian Field-Naturalist

The *Canadian Field-Naturalist* is published quarterly by The Ottawa Field-Naturalists' Club. Opinions and ideas expressed in this journal do not necessarily reflect those of The Ottawa Field-Naturalists' Club or any other agency.

PAP Registration Number 9477. Canada We acknowledge the financial support of the Government of Canada through the Publication Assistance Program (PAP) toward our mailing costs.

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Cover: A male *Pardosa hyperborea*, a small wolf spider charateristic of woods, barrens, and bogs of Newfoundland. This individual caught at Red Cliffe, Bonavista Bay, Newfoundland 3 August 2004 and photographed in the laboratory by Roy Ficken. See "An annotated list of the Spiders of Newfoundland" by J. R. Pickavance and C. D. Dondale pages 254-275.

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The Canadian Field-Naturalist

Volume 119, Number 2 April–June 2005

The Influence of Thermal Protection on Winter Den Selection by Porcupines, *Erethizon dorsatum,* in Second-Growth Conifer Forests

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Zimmerling, Todd N. 2005. The influence of thermal protection on winter den site selection by Porcupines, *Erethizon dorsatum,* in second-growth conifer forests. Canadian Field-Naturalist 119(2): 159-163.

I investigated den type selection by Porcupines (*Erethizon dorsatum*), in relation to the thermal cover provided by the den type, over a period of four winters. Porcupines used log dens, stump dens and rock dens in proportion to the thermal cover provided by each den type. Based on behavioural observations of Porcupines, I assumed that the lower critical temperature for porcupines in my study area was -4°C. Both stump and rock dens provided adequate thermal protection, under most ambient conditions, to allow Porcupines to maintain their body temperature, without increasing basal metabolic rate. In most cases rock and stump dens maintained den temperatures above -4°C until ambient temperatures reached -12°C or lower. In contrast log dens provided poor thermal protection, even in years of thick snowcover. When ambient temperatures dropped below -4°C, den temperatures within log dens were also recorded below -4°C. Log dens were used least often by Porcupines, whereas stump and rock dens were used most often. Despite the large number of potential dens available to Porcupines within the study area, den use was generally limited to three dens per porcupine per winter. The limited use of dens by an individual porcupine during winter may be related to the energetic cost of finding a new den or it may be related to specific selection criteria used by Porcupines.

Key Words: Porcupines, *Erethizon dorsatum,* winter, lower critical temperature, temperature differential, winter den, den selection, den sharing, thermal cover, thermal protection, British Columbia.

Cold temperatures can have dramatic impacts on mammals, including increasing individual mass loss and mortality rates (Moore and Kennedy 1985; Saether and Graven 1988; Sweitzer and Berger 1993). Despite the extreme cold weather conditions that may be encountered throughout the northern portions of the Porcupine's (*Erethizon dorsatum*) range, the Porcupine appears to be poorly adapted for survival in colder climates. Its dorsal pelage is sparse in comparison to other northern furbearers, and the soles of its feet are hairless and large (Folk 1966). Under winter conditions the lower critical temperature (ambient temperature at which the Porcupine must increase its basal metabolic rate above resting rate to maintain body temperature) for Porcupines is estimated to be between -12°C (Irving et al. 1955) and -4°C (Clarke 1969), which is high compared to other mammals living in northern climates (Scholander et al. 1950a, 1950b; Irving et al. 1955).

Given that Porcupines have a high, lower critical temperature, cold ambient temperatures must constitute a major energy cost for them. To survive in cold temperature conditions the Porcupine has evolved a number of physiological and behavioural adaptations (Clarke and Brander 1973; Roze 1987; DeMatteo and Harlow 1997). One of the behavioural adaptations is the use of a winter den. Sweitzer and Berger (1993) and Roze (1989) found that Porcupines alter their foraging patterns in response to cold weather and spend more time in dens. Radiometric measurements (Clarke and Brander 1973) indicate that cover above the back of a Porcupine, such as a conifer branch, reduces radiative heat loss, and presumably a winter den (not measured in the Clarke and Brander study) provides even greater thermal protection than a conifer branch.

The objective of this study was to determine the relative thermal protection provided to a Porcupine by different den structures and to examine whether Porcupines choose den types with respect to the thermal protection provided. Den switching and den sharing by Porcupines was also examined to compare winter denning behaviour of this study population with those from other areas.

Study Area

This study took place near Terrace, British Columbia, Canada (54°35', 12°42') in the Shames Valley (approximately 30 km west of Terrace; Figure 1). The study site was composed of three second-growth stands, (20-25 years old) located in the Coastal Western Hem-

FIGURE 1: Study site location within British Columbia, Canada.

lock, wet submaritime (CWH_{ws}) biogeoclimatic subzone (Banner et al. 1993). The second-growth forest consisted primarily of Western Hemlock (*Tsuga heterophylla*), Amabilis Fir (*Abies amabilis*), and Sitka Spruce (*Picea sitchensis*) with a minor component of Western Red Cedar (*Thuja plicata*). The study stands were located on a west-facing slope with gradient up to 40% present. The lower boundaries of the study stands were at approximately 200 m elevation and the upper boundaries were at approximately 450 m elevation.

Average minimum monthly temperatures varied considerably from month-to-month and from year-to-year over the four winters of the project. Fourteen of the 20 months of this study had average minimum temperatures of –4°C or lower and 6 of the 20 months had average minimum temperatures of –12°C or lower.

Methods

During the winters (November – March) of 1996 to 2000, using systematic searches of the study area, 33 Porcupines were located and captured. Once located, the Porcupine was netted, using a large dip-net, if the animal was out of its den. If the animal was in its den, a Tomahawk, single door live-trap (40 × 40 × 100 cm) was placed at the den entrance and left overnight. Once captured, the animal was drugged using a 10:1, ketamine (10 mg/kg): xylazine (1 mg/kg) combination. To reduce the time to recovery of smaller animals, 1 kg was subtracted from body weight when determining dosage. This procedure ensured that smaller animals, that could be processed more quickly and were more susceptible to exposure to cold temperatures, recovered more quickly than larger animals that required more processing time and were less susceptible to exposure to cold temperatures.

Throughout the winter months from 1996 to 2000 each collared animal was located three times per week, using handheld telemetry. When an animal was found in a den the location was recorded using a Trimble ProXL GPS unit with differential correction (accurate to ± 1 m), and a temperature measurement from inside and outside the den was made. The temperature was measured using a Barigo digital indoor/outdoor thermometer (accurate to ± 1°C) with a 3 m probe cable. The probe was taped to heavy electrical wiring to give stiffness and to allow manipulation into the Porcupine den. When the Porcupine could be seen within the den, the probe was placed beside (but not touching) the animal. When the animal could not be seen the probe was inserted to a maximum of 2 m. In all cases the probe was positioned so as not to be resting on the den floor. The probe was left for 10 minutes to gain a stable temperature reading. Once the den temperature had been recorded the probe was then removed and placed at the top of snowcover, in a forest opening closest to the den site, to record ambient temperature.

Although a single Porcupine may have used the same den over several weeks during the winter or during two or more winters, only a single temperature measurement was taken from each den site over the course of this study. In addition to the den use by collared Porcupines, den use by uncollared Porcupines was also noted (the type of den used) when discovered fortuitously. Temperatures were not recorded at these den sites unless it was confirmed (through visual observation) that the Porcupine was occupying the den at the time.

To estimate the average maximum and minimum temperature within the study area, three monitoring sites were established within the study stand. Each monitoring station had one max/min thermometer (Taylor indoor/outdoor maximum/minimum mercury thermometer) at snow level attached to the north side of a tree. These locations were visited once per week throughout the winter months and the maximum and minimum temperature for the week was recorded and averaged with the three readings. A mean monthly maximum and minimum was then calculated for each winter month using the weekly readings.

Statistical Analysis

I compared the thermal protection provided by each den type using a single factor analysis of variance of the temperature differentials for each den type. Where required a Tukey test was used to determine which means were different (Zar 1974). Temperature differentials were calculated by subtracting the ambient temperature from the den temperature to give a positive number. When den temperatures were lower than ambient temperatures the differential was negative.

Results

Porcupines within the Shames Valley study area used four distinct den types: (1) log dens, which were defined as dens within fallen, hollow logs or dens located under a fallen tree (usually having been created by trees that had been cut down during commercial harvesting, but

left on-site). (2) Stump dens, which were defined as dens located beneath the stump of a previously harvested tree. In all cases these dens were located in the rootwad of the stump, and not in any kind of hole within the stump itself. (3) Rock dens, which were dens located within the crevices of rock outcroppings. These dens were usually very deep and often had multiple, potential entrances. (4) Pre-excavated dens, which were rare in the study area, consisted exclusively of dens excavated by Coyotes (*Canis latrans*) into soft soils on gully slopes.

A total of 46 dens were measured to determine the temperature differential between den and ambient temperatures. Unfortunately, owing to the low number of pre-excavated dens used, no measurements for this den type were obtained. Rock and stump dens provided almost identical thermal protection, with mean temperature differentials of +5.4°C and +5.2 °C, respectively (Figure 2). Log dens provided the poorest insulation for Porcupines, as the best temperature differential recorded for a log den was +4°C and the mean was +1.3°C (Figure 2). This compares with the best temperature differential for a rock den of +9°C and a stump den of +10°C. Analysis of variance, with the associated Tukey test, showed log dens provide significantly less thermal protection than both rock and stump dens (ANOVA $p = 4 \times 10^{-4}$; d.f. = 2, 43; F = 9.42).

In the single case where a log den was measured while ambient temperature was below -12°C, the den temperature was also below -12°C (-16°C ambient, -15.3°C den). In nine cases where den temperatures were recorded in stump and rock dens while ambient temperatures ranged from -12°C to -20°C, the den temperatures remained above -12°C.

Of 24 observations of Porcupines out of their dens during the day, only one occurred when the ambient temperature was below -4°C (temperature was -5°C). This observation involved a Porcupine moving down a tree and travelling to a stump den, which it entered. All other observations of active animals involved Porcupines feeding or resting in trees when temperatures were between -2°C and +6°C.

If -4°C is the lower critical temperature for Porcupines, then log den temperatures were at or below the lower critical temperature in all eight cases where ambient temperature was below -4°C. Rock den temperatures were at or below -4°C in four out of twelve cases where ambient temperature was below -4°C, and stump den temperatures were at or below -4°C when ambient temperatures were below -4°C in four out of fifteen instances. In the cases where stump and rock den temperatures were below -4°C, the ambient temperature was -12°C or colder and the level of thermal protection provided by the den was high (+6.7°C to +10.0°C temperature differential).

The use of pre-excavated and log dens was similar from year-to-year, with pre-excavated dens being used in only one year (1996-1997) and log dens being used infrequently in all years (Table 1). In three of the four

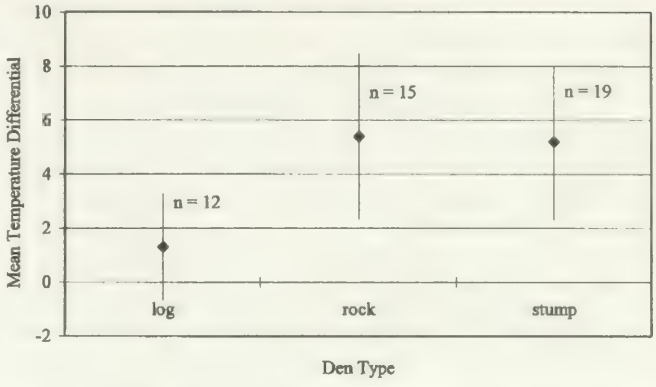

FIGURE 2: Mean temperature differential (den temperature – ambient temperature in °C) (± 1 s.d.) of winter den types used by Porcupines in the Shames Valley (All data from 1996 to 2000 combined).

years the majority of dens used were stump and rock dens, the two den types with the best temperature differentials. The biggest single change in den use, from year-to-year was in the use of stump dens in 1997-1998. During this winter, the use of stump dens dropped to the lowest usage of the study (13.8%), while the use of rock dens increased to the highest usage (69.0%) (Table 1). The winter of 1997-1998, based on average weekly temperatures, was the warmest winter of the four-year study (Table 2). January was the only month in which 1997-1998 did not have the warmest maximum and minimum average temperatures, compared to the three other study years.

The number of dens used by a single Porcupine in one winter was constant over three winters of the study. In 1996-1997, 1998-1999 and 1999-2000 individual Porcupines used an average of 3.4 dens/Porcupine, 3.3 dens/Porcupine and 3.3 dens/Porcupine, respectively. The average number of dens used by a Porcupine dropped in 1997-1998 to 2.1.

Throughout the four winters of this study individual Porcupines did not always use the same den sites from year-to-year. In some cases new dens were used every winter and in a small number of instances the same den was used by different Porcupines in two different years. Only one instance of two Porcupines using the same den at the same time was noted. This den sharing occurred in the winter of 1998-1999 and involved an adult female and a juvenile female. It was unknown if the two animals were related, but they shared the same den for 22 days without any indication of disputes occurring within the den (no sounds when den was observed by researchers).

Discussion

Porcupines in this study used four distinct den types (log, stump, rock or previously excavated dens); however, previously excavated dens were only used to a minor degree during a single winter. Unlike the results reported by Roze (1987), Griesemer et al. (1994), and Griesemer et al. (1996) all animals in this study used

TABLE 1: Winter den type selection by Porcupines in the Shames Valley (1996–2000).

Winter	n	Den Type			
		Log	Stump	Rock	Pre-excavated
1996-1997	47	17.0%	38.3%	38.3%	6.4%
1997-1998	29	17.2%	13.8%	69.0%	0.0%
1998-1999	24	12.5%	50.0%	37.5%	0.0%
1999-2000	23	17.4%	52.2%	30.4%	0.0%
Total	123	16.3%	37.4%	43.9%	2.4%

dens extensively throughout the winter and although roosting in trees during the day was noted, none spent more than a day in the shelter of conifer trees rather than in a den.

The relative use of the three common den types mirrored closely the temperature differentials found between them. Rock and stump dens had the largest temperature differentials and were used equally often through most of the study. An exception to this was the winter of 1997-1998, when rock dens were used more than in any other year and stump dens were used less often. This winter was also the warmest winter of the study. The warmer average temperature resulted in more mid-winter snowmelt than in other study years, and this may have influenced den choice by Porcupines. Stump dens tend to be low-lying and are susceptible to water seepage. As a result, increased snowmelt may have resulted in water in the den and thus lower use by Porcupines.

Log dens had the poorest temperature differential and were used least often among the three common den types. Even in years of increased snowfall, when the thick snowpack would be expected to provide increased thermal cover to a log, Porcupines did not increase the use of this den type. In all years, when ambient temperatures dropped below -4°C, log dens did not provide adequate thermal protection to Porcupines.

Roze (1989) found similar results in den use by Porcupines in the Catskill Mountains of New York State. Rock crevices were the most used denning structure (70% of dens) and hollow logs were least often used (< 10% of dens). A key difference between the Porcupines in the Catskill Mountains and the Porcupines in the Shames Valley is the use of stump dens and standing, hollow trees. In the study area chosen by Roze (1989), Porcupines used standing trees with hollow openings for dens 20% of the time, and never used stump dens, as seen in my study. The difference in den use is related to forest structure. My study site is a second-growth forest, 20–25 years of age, and, as a result, there are no trees within the study area that are old enough to have developed hollow openings in the stem. The high use of stump dens is related to previous logging activities. The removal of the large old-growth trees resulted in large stumps being left behind. As the root structure of these stumps begins to decay a natural opening is created beneath the stump in the root wad. Although Roze's study area encompassed an abandoned farm, he mentions no evidence of recent (in the last 30 years) logging on the site. As a result, stumps would only be created through natural mortality of trees. Speer and Dilworth (1978) also reported that the majority of den sites in their New Brunswick study site were located in the roots of trees. These dens, however, were not under stumps, but located in the roots of wind-thrown trees. Only one of 69 dens was located in a standing, hollow tree.

Based on behavioural observations of Porcupines during my study, I assumed that the lower critical temperature for Porcupines in the study area is closer to –4°C as reported by Clarke (1969), rather than the –12°C reported by Irving et al. (1955). In my study area, under most winter temperature conditions, Porcupines are able to rely solely on the thermal cover provided by a rock or stump den to reduce the energy requirements for maintaining body temperature, as den temperatures are maintained above -4°C. When ambient temperatures drop below –12°C, it appears Porcupines are forced to increase their metabolic rate to maintain body temperature within rock and stump dens, however, on average, temperatures within the study area were above –12°C.

Porcupines in my study were usually solitary in their den occupancy, but there was one instance where two Porcupines used the same den at the same time. The sharing of dens by Porcupines has been reported by Roze (1987), who found 12% of dens to be occupied by two Porcupines (usually a male-female pair). Dodge (1967) also described den sharing by Porcupines in western Massachusetts. In contrast, Dodge and Barnes (1975), Brander (1973) and Shapiro (1949) found that Porcupines rarely shared dens in their studies. The occurrence of winter den sharing appears to be directly correlated with the abundance of den sites in a particular area. All three studies where Porcupines were found to rarely share dens were described as having an abundance of den sites, whereas Roze (1987) describes both his study site and that of Dodge (1967) as having limited den sites. Griesemer et al. (1996) when comparing den sharing in two areas with different den availability in Massachusetts found that availability of den sites did influence den sharing by Porcupines. The results from my study also support this argument as the Shames Valley has a large number of

potential den sites (as indicated by numerous unoccupied, but previously used dens).

Despite the large number of available dens, Porcupines in the Shames Valley used only a few dens per individual during a single winter (approximately three dens/Porcupine during 1996-1997, 1998-1999, and 1999-2000). In the warm winter of 1997-1998 the average number of dens used per Porcupine dropped to two. Increased snowmelt in this year may have reduced the number of dens available to Porcupines, owing to water seeping into den sites. Alternatively, the warmer temperatures may have also increased the energetic cost of travel for Porcupines by creating a soft snowpack, thereby restricting Porcupine movements. Roze (1989) reported a similar impact, with high snowfall events reducing Porcupine winter movements and numbers of dens used.

Porcupines choose den structures in relation to the relative thermal cover provided by the structure. In the case of the Shames Valley, Porcupines are taking advantage of an abundance of stump dens, which have been created as a result of past commercial forest harvesting in the area. Given the role of the winter den in Porcupine winter ecology (Roze 1987, 1989; Griesemer et al. 1994; Zimmerling and Croft 2001) it is likely that the creation of dens with high thermal cover is increasing the areas over which Porcupines can maintain winter ranges. Without the past forest harvesting Porcupines in the Shames Valley would have been limited to rock dens. Consequently Porcupine den locations would be more confined to steep areas where rock has been exposed. With the past forest harvesting activities Porcupines can find dens with good thermal cover throughout the second-growth stand and can establish winter ranges accordingly.

Acknowledgments

This research was supported financially by Skeena Cellulose Inc., Terrace Operations, and the British Columbia Ministry of Forests, Kalum Forest District. Major funding was supplied by Forest Renewal British Columbia.

I thank M. D. Bahr, M. A. Bahr, A. Coosemans, W. Croft, C. Croft, M. Dawson, B. Delahanty, M. Hamilton, C. Jardine, K. Kranrod, P. Kranrod, M. Krisinger, J. Pylon, W. Sheridan, P. Skinner, L. Zimmerling, and R. Zimmerling for their hard work under extreme field conditions. Thanks to L. Zimmerling and C. J. Krebs for reviewing an earlier draft.

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Received 4 March 2002
Accepted 14 May 2005

Black Bear, *Ursus americanus*, Ecology on the Northeast Coast of Labrador

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Chaulk, Keith, Soren Bondrup-Nielsen, and Fred Harrington. 2005. Black Bear, *Ursus americanus*, ecology on the northeast coast of Labrador. Canadian Field-Naturalist 119(2): 164-174.

Twenty-three Black Bears (*Ursus americanus*) were captured, 20 were measured, marked and/or radio collared, in northeastern Labrador, between 1996 and 1997. Bears used sea ice for travel, coastal islands for denning, hunted adult Caribou (*Rangifer tarandus*), and were the possible cause of Moose (*Alces alces*) calf mortality. Body sizes were small, median weight of adult females was 48 kg, and the sex ratio for captured subjects was 1:1. Four of six radio-collared females gave birth during the winter of 1997, female reproductive histories suggest delayed sexual maturity. Den entry occurred between October and December 1996; spring emergence occurred between April and May 1997, with estimated denning period ranging from 148-222 days. Visual observations of habitat use by radio collared subjects (n = 10) were not tested statistically but suggest that barren areas are used nearly as much as forest. Location data from three GPS collars deployed on three adult females were analysed using Chi-square goodness-of-fit test with Bonferroni correction; two females appeared to prefer forest habitats ($p < 0.05$).

Key Words: Black Bear, *Ursus americanus*, Labrador, telemetry, home range, morphology, denning, habitat, translocation, activity.

Although the Black Bear (*Ursus americanus*) has been studied throughout most of its range, it had been virtually ignored in Labrador. This changed in 1989, when a five-year research program was initiated to document Black Bear ecology near Hebron Fiord in northern Labrador (Veitch 1992; Veitch 1994; Veitch and Harrington 1996). The Hebron bears demonstrated atypical characteristics such as heavy reliance on animal protein, home ranges orders of magnitude larger than bears to the south, and year-round activity on barren habitats, earning them the name "barren-ground Black Bear" (Veitch 1992). However, it remained unclear if bears in more southerly regions of Labrador shared these barren-ground characteristics, if they displayed characteristics more closely associated with forest dwelling bears or were intermediary between the two.

Shortly after the completion of the Hebron study in 1993, a large nickel deposit was discovered approximately 200 km to the south, near Voisey's Bay, Labrador. The anticipated development of that deposit, and the associated environmental impact assessment prompted the present study on the ecology of Black Bears in the Voisey's Bay area. This article describes observations made during 1996 and 1997 regarding Black Bear habitat use, den site characteristics, denning period, food habits, daily activity, morphology, productivity, and demographics.

Study Area

The study area (Figure 1), approximately 1600 km^2, located south of Nain, Labrador, is rugged with elevations ranging from 0 to 650 m above sea level (asl). The western section is relatively flat, with the main habitat types being heath and rock barrens. The central region is comprised of rounded topography, valleys, and depressions and the main habitat types include heath and rock barrens. The eastern portion is characterized by low-lying coastline, sheltered river valleys, and rolling hills (JWEL 1997*). The habitat mapping component of this study was defined by a 1:20 000 ecological land classification (JWEL 1997*) and comprised approximately 364 km^2 of the larger study area (Figure 1).

Weather and climate information collected by Environment Canada at Nain from 1951 to 1989 show that the mean monthly temperature varies from -19°C in January to 10°C in July, with a mean annual temperature of -3°C. Mean annual precipitation is 740 mm, with the highest monthly rainfall recorded during July (79 mm) and maximum monthly snowfall occurring in January (87 mm). Snow and ice can persist until July (Environment Canada 1989).

Methods

Human activity related to mineral exploration in the study area at the time of this study, although recent, was at an all time high, and bear-human conflicts were common. To reduce the number of bears killed, camp personnel initiated a Black Bear translocation program. In addition the study team used leg snares, and darting from a helicopter to capture Black Bears. All bears captured in culvert traps were moved away from project activities by helicopter: translocation distances

varied. For most translocations, a second helicopter was used to transport the study team to the release location. All marked Black Bears were initially tranquilized with 4-7 mg/kg of Telazol (White et al. 1996). All subjects were monitored during recovery from anesthetic and were revisited 24-30 hours after being tranquilized.

Most bears were aged, weighed, and sexed and signs of estrus (Coy and Garshelis 1992) were recorded. The senior author supervised all measurements in order to reduce researcher variation (Eason et al. 1996). Bears were marked with Flex-Lok plastic ear tags (Ketchum Manufacturing, Ottawa, Ontario). A premolar was extracted from each bear and sent to Matson's Laboratory (Montana) for cementum annuli analysis (Dimmick and Pelton 1996), which was used to determine age. For purposes of analysis and discussion, bears were classed as adults if they were 5 years and older, and sub-adults if 3-4 years of age; cubs (ages 1-2 years) were not captured or marked. The alpha-numeric code used to identify each bear was formatted as follows: age class (i.e., A,S,U), sex (i.e., M,F,U), capture sequence number (i.e., AMB01 = adult male bear number 01; SFB16 = sub-adult female bear number 16; UUB22 = Unknown sex and age bear number 22).

Seven VHF collars (Holohil Inc., Carp, Ontario) and three Global Positioning System (GPS) collars (Lotek Engineering Inc., Newmarket, Ontario), were fitted on Black Bears during June and July 1996. GPS collars weighed 1.36 kg and recorded geodetic coordinates (latitude and longitude, WGS 84), temperature, time, date, fix status, horizontal dilution of precision (HDOP), convergence (distribution of satellites above the horizon), and activity every three hours during a total of eight fix attempts/day.

Activity was measured by means of mercury switch activations; these were summed every ten minutes and averaged every three hours to provide a single activity count at the time of data logging. Activity data were summarized and expressed as a function of an average day relative to sunrise and sunset. After failure, GPS collars were retrieved and replaced with VHF collars. Two-dimensional locations were assumed to have an error radius of 50 m (Lotek Engineering Inc., 1996*); differentially corrected GPS data were assumed to have an error radius of 10 m (Moen et al. 1996); only three-dimensional (3-D) fixes were differentially corrected.

Telemetry flights were conducted between 24 June and 15 October 1996 using a Bell 206B helicopter. Once a radio signal was localized to a small area (100 m radius), an effort was made to acquire a visual fix. When a visual fix was not possible, the subject's location was estimated. The helicopter's GPS was used to record the location of all observations. Ground telemetry was conducted during the same period when aerial telemetry or animal handling were not in progress. GPS locations obtained from the helicopter and

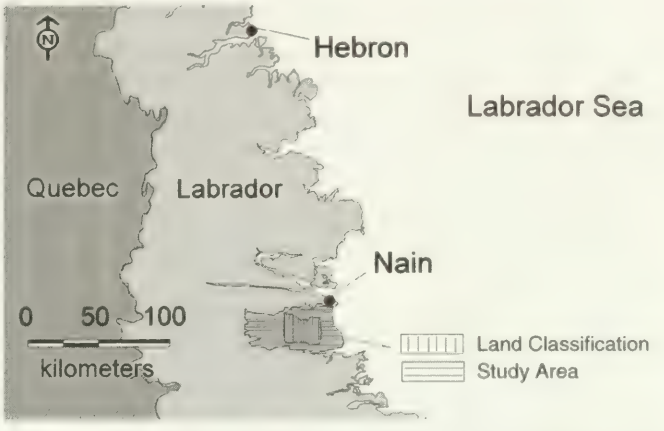

FIGURE 1. Black Bear Study Area Voisey's Bay Labrador 1996 and 1997.

handheld GPS units were not differentially corrected and were assumed to have an accuracy of +/-100 m (Moen et al. 1996); geodetic data were recorded in World Geographic System (WGS) 84 latitude and longitude, and were converted to latitude and longitude, North American Datum 83 using MAPINFO.

We searched for den sites in October and November 1996, while conducting ground and aerial telemetry. Frequency of monitoring flights was reduced after October. Monitoring flights were conducted on 3, 4 and 29 November 1996. Known Black Bear dens were monitored for activity on a monthly basis from January to March 1997. In the spring of 1997 four aerial monitoring sessions were conducted to determine the timing of den emergence (10 April, 26 and 27 April, 25 May, and 12 June). Due to gaps in monitoring we were not able to determine exact dates for either den entry or emergence. For example, the maximum date of den entry was the date the study team was able to confirm if a bear had entered its den. The minimum date of den entry is the date of the prior survey when the bear was still active. The converse was done for den emergence. We assumed each bear entered/exited its den halfway between the minimum and maximum dates of den entry/emergence. However, for ease of calculation the estimated den occupancy as the difference (in days) between maximum date of den entry in 1996 and the maximum date of den emergence in 1997.

Den sites were assigned to three habitat types: forest, barren, and other based on visual inspection of the surrounding landscape. Forest habitat was any area with canopy height exceeding 1 m, barren habitat was any non-wetland area with less than 5% canopy cover. Visual observations of radio collared Black Bear habitat use was recorded in the field, and habitats were classed using the same criteria as den site habitat classification. Visual observations reported in this study were not tested for selection because many of the observations occurred outside the area described by the 1:20 000 digital vegetation maps, and therefore habitat availability could not be calculated.

As part of the environmental baseline research for the Voisey's Bay Environmental Impact Statement (EIS), digital habitat maps (1:20 000) were developed based on interpretation of aerial photography and ground surveys (JWEL 1997*); 21 habitat classes were differentiated. However, given the limited number of locations per subject in each habitat type, we grouped these 21 habitat classes into three broad categories: barren, forest or other.

For the three GPS collared bears, Minimum Convex Polygons (MCP) and habitat maps were used to estimate habitat availability. Observed versus expected habitat use was tested for evidence of habitat selection using Chi-square goodness of fit (Neu et al. 1974). If the test was significant at $p < 0.05$, availability was compared to the 95% confidence interval (CI) for that habitat. The 95% CI was based on the normal approximation to the binomial distribution, with a Bonferroni correction for multiple testing (Neu et al. 1974). Throughout the text ± is used to represent standard deviation, whereas in the tables it is denoted by SD.

Results

There were 44 capture events (23 bears, 20 of these were marked, and 11 were captured on more than one occasion) between June and November 1996 (Table 1). Sex and age were not determined for three subjects, as camp officials captured and released these bear without participation by the study team. Twenty Black Bears were marked with ear tags and/or radio-collars, but no more than 10 Black Bears were fitted with radio-collars at any given time. Culvert traps and leg snares accounted for 27 and 9 captures respectively, one bear was darted from helicopter (Table 1).

Of the 20 marked bears, 10 were male and 10 were female. Of the 22 bears that were assigned to an age class, 10 were sub-adult and 12 were adult; cementum analysis revealed ages from 2 to 23 years (Table 1). The mean cementum age of adult males was 12.5 ± 7.0 years (n = 4), the mean cementum age of adult females was 9.1 ± 3.6 years (n = 8). The mean age of sub-adults was 2.8 ± 0.8 year (n = 5). The mean age of all males was 8.1 ± 7.4 years (n = 10), and the mean age for all females was 8.0 ± 3.0 years (n = 10). Thirty percent of bears were 10 years or older, and 67% were older than 6 years (n = 17). AMB18 was radio tracked and observed in spring of 1997, making it 24-years-old at time of last contact (Table 1).

Two of 10 females were in estrus at the time of capture (AFB02 and AFB04). Two opposite-sex pairs of Black Bears were observed together for extended periods during July 1996. Only one collared bear (AFB07) was actively caring for cubs during 1996; this family group was still intact at the time of den emergence in 1997. According to reproductive histories based on cementum analysis, only AFB06 had given birth prior to 1996, at ages 6, 9, and 11 years; AFB06 also produced cubs for the fourth time at the age of 14 during the winter of 1997. Radio tracking during the spring of 1997 showed that four of the five collared females gave birth during the winter of 1997; the mean age at first reproduction was 8 ± 1.6 years (range = 6 – 10 years). (Table 2).

Based on analysis of cementum annuli two females, AFB03 and AFB04, had not reproduced at the time of capture (age 7 and 6, respectively). Five of seven females (71%) produced cubs over a two-year period. From 1996 to 1997, 11 cubs of the year (COY) were produced, mean = 1.8 ± 1.0 cubs/adult female, n = 6 (Table 2), the mean annual rate of reproduction = 0.8 ± 0.6 cubs/female/year (range 0-1.5, n = 7).

Fifteen bears were translocated a total of 25 times (Table 3). Estimated return periods from translocation point to capture site for 11 bears ranged from 1-55 days (mean = 18.3 ± 19.0 days); estimated rate of return ranged from 0.5 km/day to 6.5 km/day with mean rate of return of 2.6 ± 2.2 km/day (Table 3). Four bears in the study area were shot by mining camp and provincial wildlife officials in 1996: two were collared (AMB01 and SMB11), one was tagged (AMB19), and one was unmarked (UMB17). Three bears died during 1997: SFB16 (natural causes), SMB13 (shot by hunter), and SMB10 (shot by camp personnel) (Table 1). Six of seven known mortalities were males (three adults, two sub-adults, one age unknown). A post-mortem examination of AMB19 at the Atlantic Veterinary College (University of Prince Edward Island, Charlottetown) showed that this bear had previously been shot and had been suffering from lead poisoning for approximately six weeks prior to its death. No Black Bears died as a result of capture or handling by the study team.

Between June and October 1996, weights and physical measurements were recorded for 20 adult and sub-adult bears. Weights for all subjects ranged from 27 to 130 kg (n = 20); adult males (120 ± 19 kg, n = 4) were about twice as heavy as females (48 ± 13 kg, n = 8). The heaviest male and female were 8 and 7 years old, respectively. Chest measurements for all subjects ranged from 64 to 112 cm (n = 18) with adult males averaging 103 ± 13 cm (n = 4) and adult females 87 ± 8 cm (n = 7).

Activity counts from the GPS collars were averaged and graphed to represent mean daily activity. Minimum daily activity occurred 2-3 hours after sunset (23:00). Peak activity occurred 3-4 hours before sunset (17:00). Activity was relatively constant across other time intervals (Figure 2).

Eighteen den sites were located during 1996: 7 in forest, 6 in barren and 5 in shrub thicket (Table 4). The entrance to all dens faced south or southwest. Eight dens were unoccupied and were located prior to the start of fall denning; 10 dens were located after denning. One bear left the mainland in late summer 1996 and took up residence on a large coastal island where it excavated a den in a sandy spot underneath a shrub

TABLE 1. Capture Information for Black Bears in the Voisey's Bay, Labrador study area, 1996-1997.

ID	Mark*	Field Age	CA Age	Diff **	Sex	Captures	Culvert	Snare	Air	Deaths 1996	Deaths 1997	Comments
SMB00	E	3			M	3	3					First bear ear tagged
AMB01	E/V	12	10	-2	M	3	1	1		1		Destroyed by camp officials
AFB02	E/G/V	6	7	1	F	3	1	1	1			GPS collar replaced August (96)
AFB03	E/G	6	7	1	F	1		1				GPS collar recovered after 3 days
AFB04	E/G/V	6	6	0	F	2		2				GPS collar replaced August (96)
AMB05	E/V	8	8	0	M	1	1					Lost contact June (96)
AFB06	E/V	8	13	5	F	1	1					
AFB07	E/V	6	10	4	F	1		1				
AFB08	E/G/V	3	6	3	F	3	2	1				GPS collar replaced August (96)
AFB09	E/V	3	8	5	F	2	2					
SMB10	E/V	3	2	-1	M	3	2				1	Destroyed by camp officials
SMB11	E/V	3			M	2	1			1		Destroyed by camp officials
AFB12	E	5	16	11	F	4	4					
SMB13	E	3	2	-1	M	2	1				1	Killed by local hunters
SFB14	E	3	3	0	F	1		1				
SMB15	E	3	3	0	M	1		1				
SFB16	E/V	4	4	0	F	3	2				1	Died of natural causes
SMB17		3		-3	M	1				1		Destroyed by government officials
AMB18	E/V		23	23	M	1	1					Last bear collared, oldest bear
AMB19	E	5	9	4	M	3	2			1		Destroyed government officials
UUB20						1	1					First bear captured, not marked
UUB21						1	1					Captured/released camp officials
UUB22						1	1					Captured/released camp officials
Count		19	17	18		23	17	8	1	4	3	
Mean		5	8	3		2	2					
Median		4	7	0		2	1					
SD		2.4	5.4	6.0								

E = ear tagged, V = VHF collar, and G = GPS collar ** Difference between Field Age and CA (cementum annuli) age.

TABLE 2. Summary of Cubs of the Year (COY), Reproductive History and Age at first Birth for marked adult female Black Bears in Voisey's Bay, Labrador study area during 1996 and 1997. Age at first Birth, and Reproductive History were discerned through analysis of cementum annuli (Coy and Garshelis 1992).

ID	Age (96)	(COY) 1996	1997	Total COY	Annual Rate (COY)	Age at first birth	Reproductive History
AFB02	7	0	2	2	1	8	In estrus June (1996)
AFB03	7	0		0	0		Lost contact with this bear in June 1996
AFB04	6	0	0	0	0		In estrus June (1996); non-productive (1996 & 1997)
AFB06	13	0	2	2	1	6	Cubs at age 6, 9, 11, & 14 (1997)
AFB07	10	2	0	2	1	10	Two cubs at time of capture in June (1996)
AFB08	6	0	3	3	1.5	7	
AFB09	8	0	2	2	1	9	
Count	7	7	6	7	7	5	
Sum		2	9	11	5.5	40	
Mean	8.0	0.3	1.5	1.6	0.8	8.0	
Median	7.0	0.0	2.0	2.0	1.0	8.0	
SD	2.5	0.8	1.2	1.1	0.6	1.6	

thicket (Table 4). Three radio collared females entered dens by mid-October 1996. A mother with two cubs (AFB07), left her den in late October and moved to a second den by early November. Six other bears (5 females and 1 male) entered their dens by late November, while one bear, AMB18 was still active on 29 November 1996 (Table 4). In 1996, Black Bears were first sighted in March. Monitoring flights conducted in 1997 found that 10 of 11 radio-collared bears had emerged from their dens between 27 April and 27 May, 1997. The mean length of the estimated den period was 190 days ± 28.2 days (n = 9).

A total of 185 visual observations were made of Black Bear habitat use based on aerial tracking of VHF collared subjects: subjects were observed in forest on average 54% ± 21.5, barrens = 40% ± 25.7, and other = 6% ± 7 (Table 5). Individual bears varied in their relative use of barren and forest habitats. For example, 86% of AFB02's locations (n = 28) were on barrens, whereas only 10% of AFB08's locations (n = 20) occurred in similar habitat (Table 5).

Three adult female Black Bears were tracked using GPS collars during July and August, 1996 (n = 24, 45 and 56 locations, respectively). Bear locations most commonly occurred in forest habitats: Spruce/Fir/Dwarf-Shrub, Birch Thicket, Black Spruce Lichen, and Tuckamore. Chi-square analysis of gross habitat indicated that two bears (AFB04 and AFB08) occupied habitats differently from availability ($p < 0.02$); they appeared to prefer forest more than the other two primary habitat types. The other subject (AFB02) appeared to use all three habitats in accordance with availability (Table 6); forest habitat comprised 65% of her home range. During May and June the study team observed three incidences of Black Bears walking on sea ice up to 2 km from shore.

Two incidences of ungulate predation/scavenging by Black Bears were observed during 1996. The first incident occurred in April and involved an unmarked adult male Black Bear attacking an adult female Caribou (*Rangifer tarandus*), which later died from its wounds and was partially eaten by the bear. The second incident occurred during an unsuccessful attempt to dart a Black Bear from helicopter in June 1996. The Black Bear was observed walking along an esker near a river. As we circled to dart the bear, it ran to the river and retrieved a dead Moose (*Alces alces*) calf and proceeded to run with the carcass in its mouth for approximately 50 m. The bear then dropped the carcass and ran into the forest. An adult female Moose was seen within 200 m of the carcass.

Discussion

After the Muskox (*Ovibos moschatus*), Black Bears have the lowest reproductive rate of any land mammal in North America (Jonkel and Cowan 1971). Elowe and Dodge (1989) reported ages at first reproduction for a hunted population of Black Bears in Massachusetts; mean age at first reproduction was 3.7 ± 0.7 years

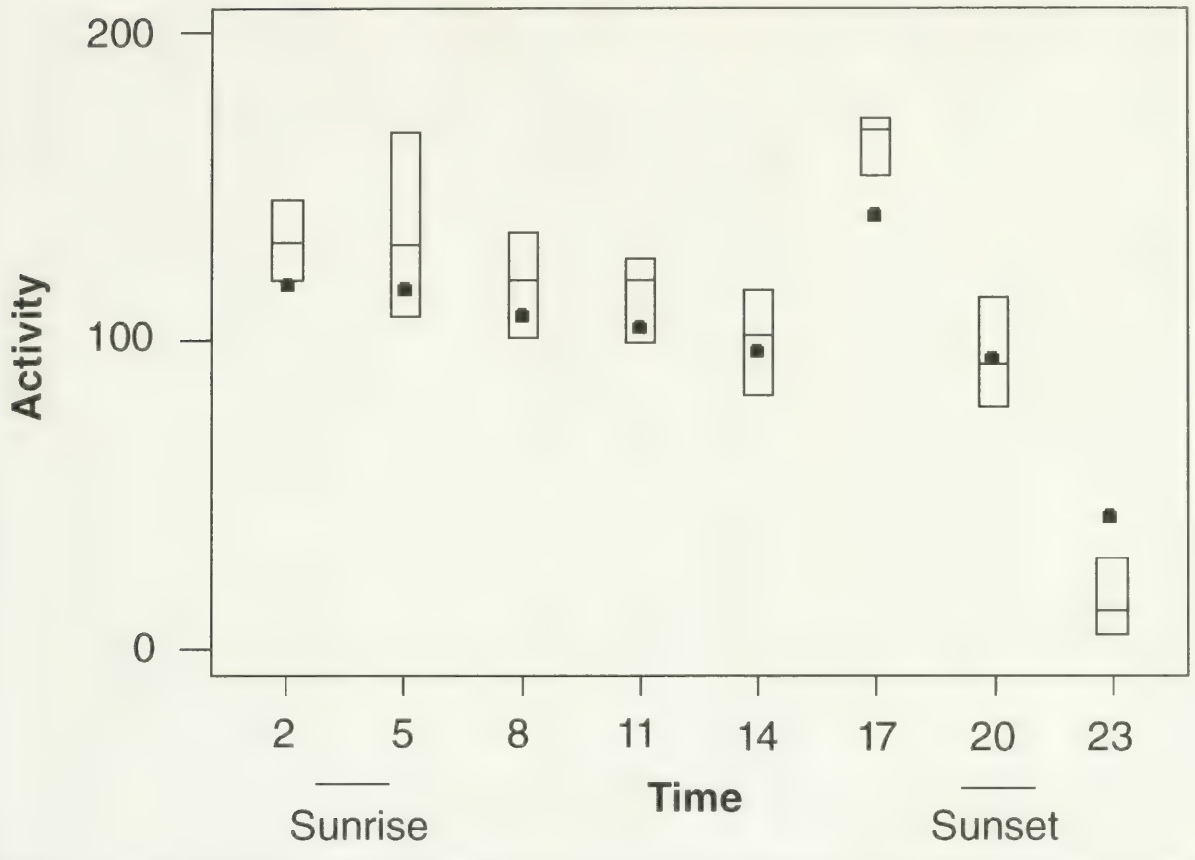

FIGURE 2. Mercury Switch Activations (Activity) averaged over 8, three-hour time periods for three adult female Black Bears near Voisey's Bay, Labrador. Observations were downloaded from data loggers housed in the GPS collars and occurred over 50-day period from 25 June to 13 August 1996 (n = 1080). The range of times for sunrise and sunset during this period are shown on the x-axis. On 25 June sunrise occurred at approximately 03:19 and set at 21:03 Atlantic Daylight Savings Time (ADST); on 13 August sunrise occurred at 04:32 and set 19:53 (ADST), times for sunrise and sunset are based on an elevation of 400 m for the community of Nain, Labrador (Environment Canada 1998). Dark squares indicate mean activity. Horizontal lines indicate the 95% Confidence Interval for the median.

(range 3 – 5). Rogers (1993*) reported that the age at first reproduction for wild bears in eastern Minnesota was 6.3 years (n = 17). The mean age at first reproduction for females in our study area was 8 years, 30% older than wild bears in Minnesota (Rogers 1993*) and 54% older than bears in Massachusetts (Elowe and Dodge 1989).

Black Bear productivity in the Voisey's Bay area was much higher than reported by Veitch and Harrington (1996) in northern Labrador. They tracked eight adult females for 22 bear years and during this time cubs accompanied females in 3 years (14%). In our study seven females were tracked for an equivalent of 13 bear years, and during this time cubs accompanied females in 5 years (38%).

Due to logistical constraints we were not able to determine litter size at birth, so direct comparison with litter sizes in other areas of North America are difficult. We were able to document the number of cubs with each marked female during 1996 and spring of 1997. During this period 7 females produced 11 cubs (1.6 ± 1.1 cubs/female, n = 7); however, if we exclude females that did not produce cubs the average number of cubs/female increases to 2.2 ± 0.4 (n = 5). This compares to an average litter size = 2.4 cubs/female in Massachusetts (Elowe and Dodge 1989) and average litter sizes ranging from 2.1 to 3.4 cubs/female in Minnesota, where litter size varied with foraging behaviour and reproductive history (Rogers 1993*).

We did not include observations of cubs associated with marked females in our capture statistics. In our study we found that sub-adults comprised 48% and adults 52%. Young and Ruff (1982) conducted a removal experiment on a population of Black Bears in central Alberta. For comparison purposes, we excluded cubs from their pre-removal capture data (1968-1971) and recalculated age structure statistics; sub-adults comprised 28% and adults 72% (n = 302). Kohn and Rolley (2000*) tabulated age structure data for bears harvested during 1998-1999 in Wisconsin. We re-calculated their age structure statistics with cubs excluded; sub-adults comprised 54% and adults 46% (n = 1664). Based on these comparisons the age structure of our study set was older than that reported in Wisconsin (Kohn and Rolley 2000*) and younger than that reported in Alberta (Young and Ruff 1982), albeit our sample sizes were very small in comparison.

Six of 21 bears died during our study period translating into a 28.6% mortality rate; all were male and five were sub-adult. No bears died as a result of handl-

TABLE 3. Summary of Black Bear translocation and homing near Voisey's Bay, Labrador during 1996.

ID	Captures	Translocations	Date	Distance (Km)	Return Period (days)[1]	Rate of Return km/day
SMB00	3	3	06/19/96	1	1	1.0
			08/19/96	30		
			10/08/96	26		
AMB01[2]	3	1	08/02/96	13	2	6.5
AFB02[2]	3	1	07/29/96	31	6	5.2
AFB03	1					
AFB04[2]	2					
AMB05	1	1	06/23/96	25		
AFB06[2]	1	1	06/23/96	12	22	0.5
AFB07[2]	1					
AFB08[2]	3	2	07/10/96	12	5	2.4
			08/22/96	23	8	2.9
AFB09[2]	2	2	07/31/96	16	10	1.6
			08/11/96	56		
SMB10[2]	2	2	07/31/96	13	4	3.2
			08/31/96	52		
SMB11[2]	2	1	08/01/96	20	55	0.4
AFB12	4	4	08/01/96	27	7	3.9
			08/08/96	56	9	6.2
			08/18/96	32	33	1.0
			09/20/96	42		
SMB13	1	1	08/02/96	26		
SFB14	1					
SMB15	1					
SFB16[2]	2	2	08/26/96	26		
			10/05/96	18		
SMB17	1					
AMB18	1	1	10/21/96	13		
AMB19	3	2	08/27/96	35	48	0.7
			10/18/96	23	46	0.5
UUB20	1	1	06/19/96	18		
Count	21	15	25	25	14	14
Mean	1.9	1.7	08/13/96	25.8	18.3	2.6
Median	2	1	08/08/96	25	8.5	2
SD	1.0	0.9	35.9	14.0	19.0	2.2
Range	3	3	124	55	54	6.1

[1] Based on estimated return date to capture site; some subjects may have returned sooner than indicated.
[2] Radio collared subjects

ing. If we only include bears that died of natural causes the mortality rate of marked bears drops to 4.5%. The impact of these losses on the local Black Bear population remains unknown. In Labrador, for much of the 1980s and 1990s a single Black Bear license provided a quota of five bears per year; this has since been reduced to two bears per year (D. Blake personal communication). It is unclear how many Black Bears were harvested annually in the study area when the Black Bear quota was at its highest, but given the weak fur market and lack of a sport hunt, the harvest was probably low compared to elsewhere in Labrador.

Estimates by provincial wildlife officials suggest that bear mortalities in the study area averaged about one per year from 1998-2003 (F. Phillips, D. Blake personal communication). In 2003, mining camp officials recorded over 300 bear sightings. In total four Black Bears were captured, of these two were translocated and two were destroyed (D. Lampe personal communication). While not rigorous, this information seems to suggest that in 2003 Black Bears were still relatively abundant in the study area.

Although not an initial goal of the study, we also tracked the effectiveness of bear translocation and homing. Our results were consistent with observations of bear homing in other areas (Rogers 1986); most translocated bears (75%) eventually returned to the capture area, generally within 1-2 weeks.

Mahoney et al. (2001) analysed body mass for Black Bears from various regions of North America. The lowest average weight for adult females were from Quebec at 54 kg, and the highest from insular Newfoundland at 101 kg; the lowest average weight for adult males was reported in Maine at 116 kg, and the highest from insular Newfoundland at 178 kg. The median weight of adult females from our study (48 kg)

TABLE 4. Approximate Den Entry and Emergence Information and estimated denning period for Black Bears in the Voisey's Bay, Labrador study area, 1996-1997. The estimated den period is based on the difference between maximum den entry date and maximum den emergence date.

ID	Habitat	Maximum Den Entry Date	Minimum Den Entry Date	Minimum Den Emergence Date	Maximum Den Emergence Date	Estimated Den Period (Days)	Comments
AFB02	Forest	11/04/96	11/29/96	04/26/97	05/27/97	179	
AFB04	Barren	10/10/96	10/18/96	04/26/97	05/27/97	221	
AFB06	Barren	10/10/96	10/17/96	04/26/97	05/27/97	222	
AFB07	Barren	10/10/96	11/04/96	04/26/97	05/27/97	204	1st den 10/18, moved to 2nd den by 11/04
AFB08	Barren	11/04/96	11/29/96	04/10/97	04/26/97	148	First bear to emerge in '97
AFB09	Forest	10/18/96	11/03/96	04/26/97	05/27/97	205	Moved to 2nd den during the winter
SFB16	Barren	10/18/96	11/04/96	04/26/97	05/27/97	204	Died shortly after emergence
SMB10	Other	11/04/96	11/29/96	04/26/97	05/27/97	179	Denned on Kikkertavak Island
AMB18	Other	11/29/96	01/15/97	05/27/97	06/12/97	148	Still active on 11/29/96
Unoccupied Den	Forest						Found by camp personnel
Unoccupied Den	Forest						The next two dens were within 3 m^2
Unoccupied Den	Forest						Adjacent to above
Unoccupied Den	Forest						Adjacent to above
Unoccupied Den	Forest						
Unoccupied Den	Other						
Unoccupied Den	Other						
Unoccupied Den	Other						
Count	18	9	9	9	9	9	
Min		10/10/96	10/17/96	04/10/97	04/26/97	148	
Max		11/29/96	01/15/96	05/27/97	06/12/97	222	
Range		50	90	47	47	74	
Median		10/18/96	11/04/96	04/26/97	05/27/97	204	
Mean		10/25/96	11/14/96	04/27/97	05/25/97	190	
SD		16.9	29.5	12.2	12.2	28.2	

TABLE 5. Visual observations (n=185) of Gross Habitat use as percent use by radio collared black bears (n=10) near Voisey's Bay Labrador, from June to November, 1996. Habitats were visually classed as either barren, forest, or other at time of data collection.

Bear ID	N	Barren (%)	Forest (%)	Other (%)
AMB01	11	27.3	63.6	9.1
AFB02	27	40.7	51.9	7.4
AFB04	28	85.7	14.3	0.0
AFB06	19	26.3	73.7	0.0
AFB07[1]	22	68.2	31.8	0.0
AFB08	20	10.0	80.0	10.0
AFB09	17	11.8	70.6	17.6
SMB10	14	28.6	57.1	14.3
SMB11	14	35.7	64.3	0.0
SFB16	13	69.2	30.8	0.0
Count	185	80	95	10
Mean	18.5	40.4	53.8	5.8
Median	18	32.2	60.4	3.7
SD	5.8	25.7	21.5	6.8

[1] AFB07 was caring for two cubs in 1996.

TABLE 6. Summary of Chi-square goodness of fit test for evidence of selection. The 95% CI were based on the normal approximation to the binomial distribution, with a Bonferroni correction for multiple testing. MCP home range was used to delineate habitat availability.

Bear ID	Habitat	Area (Km^2)	Observed	Expected	(obs-exp)^2/exp	Proportion Available	95% CI Lower	95% CI Upper
AFB02								
	Barren	10.07	5	8.23	1.27	0.18	-0.00	0.22
	Forest	35.97	32	29.38	0.23	0.65	0.55	0.87
	Other	9.05	8	7.39	0.23	0.16	0.04	0.31
	Total	55.09	45	45				
	χ^2				1.73			
	df				2			
	P-value				0.46			
AFB04								
	Barren	8.91	6	10.42	1.87	0.43	0.05	0.53
	Forest	8.61	17	10.07	4.78	0.42	0.63	1.03
	Other	3.01	1	3.52	1.80	0.15	-0.06	0.16
	Total	20.53	24	24				
	χ^2				8.45			
	df				2			
	P-value				0.01			
AFB08								
	Barren	13.37	7	17.23	6.08	0.31	0.02	0.23
	Forest	27.65	48	35.63	4.29	0.64	0.75	0.97
	Other	2.43	1	3.14	1.68	0.06	-0.02	0.06
	Total	43.45	56	56				
	χ^2				12.05			
	df				2			
	P-value				0.00			

were slightly lower than those reported from Quebec by Mahoney et al. (2001). The median weight of adult males in our study (120) was slightly higher than males from Maine. In general the median weight for our subjects was comparable to the lowest average weights reported by Mahoney et al (2001) and to weights reported for Black Bears in northern Labrador by Veitch and Harrington (1996).

Daily activity patterns arise in response to seasonal and diurnal variation in the environment (Nielsen 1983). Black Bears are generally considered diurnal, a view substantiated by Amstrup and Beecham (1976),

Lindzey and Meslow (1977), and Lariviere et al. (1994). Lariviere et al. (1994) found that Black Bears in Gaspesie National Park commenced daily activity approximately 0.5 hours after sunrise, and ceased activity approximately 2.5 hours after sunset. These results are similar to those observed in our study. The activity sensors revealed greatest activity in late afternoon several hours before sunset, and minimal activity about 2-3 hours after sunset. However, our bears appeared to resume activity later in the night, several hours before dawn. Unfortunately the batteries in the GPS collars failed in mid-August and the short life span of the GPS collars prevented analysis across seasons.

In Maine, Schooley et al. (1994) reported denning periods ranging from 134 to 197 days, with entry occurring in October and November and emergence occurring in April. In Alberta, Tietje and Ruff (1980) reported numbers that translate into a median denning period of 171 days, with average den entry occurring in October and emergence in April. In northern Labrador, Veitch (1994) reported denning periods ranging from 180-220 days. The estimated denning period for bears in our study area ranged from 148 to 222 days (median = 204 days), with the median emergence occurring in May. Our data for both entry and emergence are limited due to the frequency of monitoring during the fall and spring periods. As reported our data are similar to those for barren-ground Black Bears, but in reality they may be intermediary between bears in northern Labrador and elsewhere.

In northern areas where large hollow trees are uncommon, bears tend to use excavated dens lined with plant material (Fuller and Keith 1980; Tietje and Ruff 1980; Klenner and Kroeker 1990). All known dens in our study were excavated, den roofs were supported by the root systems of the adjacent vegetation, and all entrances faced south or southwest, possibly to minimize exposure to north winds and to increase exposure to sunlight.

MCP home ranges based on 1.5 months of GPS location data were used to determine the habitat availability boundary of each subject. At least two adult females occupied forested habitat disproportional to their availability during the period July-August. The most commonly used habitat classes appeared to be Spruce/Fir/Dwarf Shrub, Birch Thicket, Black Spruce/Lichen, and Tuckamore. However, subject sample size (n = 3), location sample size (n = 24-56), time frame (1.5 months), and geographical extent of base mapping place restrictions on generalizing habitat selection behaviors to other individuals. If Black Bears in the study area prefer forest to barren habitats it did not seem to be supported by visual observations of the VHF radio collared bears, where 3 of 10 were found more often on barrens than in forests. However, the visual observations occurred over a large region and habitat availability could not be determined, so statistical analysis of habitat use relative to availability could not be conducted.

Schwartz and Franzmann (1989) found that Black Bears in Alaska accounted for 80% of Moose predation and 70% of Moose mortality; however, even there Moose predation provided only a small proportion of the overall Black Bear diet. We observed two incidences of ungulate predation/scavenging in our study during 1996; these corroborate findings elsewhere (Schwartz and Franzmann 1989; Veitch and Krizan 1996).

At the outset of the study we were curious which characteristics, if any, were similar: to the barren ground Black Bears in northern Labrador, to bears elsewhere, or were intermediary between the two. We found that habitat use was likely to be intermediary between bears in northern Labrador and bears from other regions of North America. Cub production, homing, daily activity patterns, and den site construction, were similar to that reported from other regions of North America. However, the small body size was most similar to barren ground Black Bears from more northerly regions of Labrador.

Acknowledgments

Thanks for personal communications are due to D. Blake and F. Phillips (Department of Forest Resources and Agrifoods, Newfoundland and Labrador), A. Veitch (Department of Resources, Wildlife and Economic Development, Northwest Territories), and D. Lampe (Labrador Inuit Association, Newfoundland and Labrador (NL). Thanks for support of this project are extended to J. Rowell (Labrador Inuit Association, NL), B. Napier (INCO, Ontario), P. Trimper (Jacques Whitford Environment Limited, NL), and L. Cijnak-Chubbs. Thanks for assistance in the field are due to G. Chaulk, M. Michelin, B. Duffett, B. Mactavish, M. Davis and the many pilots at Canadian Helicopters who participated in this study. Thanks are also extended to the Labrador Inuit Association and the Nasivvik Centre, University of Laval, for providing graduate funding.

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Received 18 May 2001
Accepted 7 March 2005

Long-tailed Weasel, *Mustela frenata,* Movements and Diggings in Alfalfa Fields Inhabited by Northern Pocket Gophers, *Thomomys talpoides*

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Proulx, Gilbert. 2005. Long-tailed Weasel, *Mustela frenata,* movements and diggings in alfalfa fields inhabited by Northern Pocket Gophers, *Thomomys talpoides*. Canadian Field-Naturalist 119(2): 175-180.

Little is known about the movements of Long-tailed Weasels (*Mustela frenata*) in alfalfa (*Medicago* spp.) fields inhabited by Northern Pocket Gophers (*Thomomys talpoides*). In central Alberta, I intermittently followed the movements of Long-tailed Weasels during two consecutive winters. Three types of movements were observed: straight-line movements across the fields; sinuous movements along the edges of the field; and arc movements within the field, over concentrations of Northern Pocket Gopher burrow systems. Arc movements were 0.6-28-m-wide at their base, and extended from 6 to 45 m into the field. Movements of Long-tailed Weasels into the fields were accompanied by fresh diggings in Northern Pocket Gopher burrow systems, which became inactive thereafter. This study suggests that Long-tailed Weasels may have a cognitive map of the distribution of Northern Pocket Gophers in their home range.

Key Words: Long-tailed Weasel, *Mustela frenata*, Northern Pocket Gopher, *Thomomys talpoides*, Alfalfa fields, cognitive map, movements, Alberta.

In agricultural areas, Long-tailed Weasels (*Mustela frenata*) are associated with waterways and habitats with abundant prey, such as fields with pocket gopher (*Geomys* spp. and *Thomomys* spp.) burrow systems that are inhabited by several small terrestrial species (Vaughan 1961; Gamble 1980; Whittaker et al. 1991). Criddle and Criddle (1925) suggested that, in winter, weasels entered burrow systems to kill the resident pocket gopher and other rodents. Andersen and MacMahon (1981) suggested that a low survival rate in a population of Northern Pocket Gophers (*Thomomys talpoides*) was probably due to a sudden influx of weasels. Proulx and Cole (1998) identified Northern Pocket Gopher remains in Long-tailed Weasel scats. Although a predator-prey relationship between the two species undoubtedly exists, little is known about Long-tailed Weasel movements in fields inhabited by Northern Pocket Gophers.

Weasel foraging behavior has been described as a random search during which the animals explore every likely place for small prey (Powell 1978; King 1989). Soper (1964) considered that they wander erratically from place to place, visiting vegetation clumps, burrow openings, and boulders. In this study, I hypothesized that Long-tailed Weasels would investigate Northern Pocket Gopher burrow systems as they encounter them along their wanderings.

Study Area and Methods

This project study was carried out in two study areas along the Vermilion River approximately 4 km from Vegreville (53°N, 112°W), Alberta. Study areas were bordered by thickets of willow (*Salix* spp.) and aspen (*Populus tremuloides*), high grass, and alfalfa (*Medicago* spp.) fields inhabited by Northern Pocket Gophers.

1998-1999

Study Area I was surveyed for Long-tailed Weasel tracks 10 times from 18 November to 22 December 1998, when snow was ≤ 30 cm deep and without crust, and 15 times from 14 January to 30 March 1999, when snow was deeper and with crust. Air temperatures ranged from -29°C to 9°C. A female adult Long-tailed Weasel (track length: 3.8 cm; distance between jumps ≥ 45 cm) was captured on 6 December in a mesh trap, anesthetized in a veterinary clinic with isoflurane, ear-tagged, and radio-collared (2.5 g collar with loop antenna; Holohill Systems, Ottawa, Ontario). Because weasels are very sensitive to handling and collaring (Delattre et al. 1985), the animal was kept in captivity overnight, then released at the original capture site, and intermittently located from 6 to 22 December, at which time the radio-collar ceased to emit. Radio-telemetry was used to locate the Long-tailed Weasel's dens. Snow-tracking was used to determine the extent of the Long-tailed Weasel movements along the creek and in the alfalfa field. When following the animal, fresh diggings into the dirt were flagged and re-visited the following spring. Tracks of Mink (*Mustela vison*) and Short-tailed Weasel (*Mustela erminea*) were also identified on the basis of tracks and stride characteristics (Murie 1975; Rezendes 1992).

Study Area II was surveyed four times from 24 November to 22 December 1998, and six times from 15

January to 11 March 1999. The tracks of one Long-tailed Weasel, judged to be a male according to the size of its tracks (track length: 6.3 cm; distance between jumps ≥ 65 cm), were found and followed. Because of very cold nights, often below -20°C, no attempt was made to live-trap the animal. Tracks of Short-tailed Weasels were observed across the alfalfa field.

Animal movements and diggings were originally plotted on 1:20 000 scale maps drawn from air photos (Alberta Environmental Protection, Air Photo Service, Edmonton, Alberta). In April 1999, immediately after snow melting, the distribution of Northern Pocket Gophers in Study Area I was determined using dirt mounds (piles of soil pushed to the surface of the ground by pocket gophers). Because the animals' tunnel network may extend past the border delineated by the mounds (Proulx et al. 1995), boundaries delineated with dirt mounds were extended another 3 m to the outside. In Study Area II, Northern Pocket Gopher burrow systems were sparsely distributed across the alfalfa field and were not plotted on a map. Sites where Long-tailed Weasel tracks were recorded in the alfalfa field were visited in the spring and inspected for signs of Northern Pocket Gophers.

2000

One Long-tailed Weasel was followed four times in Study Area I from 4 to 31 January 2000, when temperatures ranged from -15°C to -5°C. A crust was present after 8 January, and tracking conditions were difficult. Although tracks were identical to those of the female studied the previous year, it is not sure that this was the same animal. Overlap between Long-tailed Weasel tracks and Northern Pocket Gopher burrow systems was determined using the presence of mounds, and the pocket gopher distribution map developed the previous year.

Results

Habitats

In 1998-1999, the female's movements encompassed an 8-ha area comprising approximately 1.3 km of the Vermilion River, and a continuous alfalfa field (Figure 1). Two dens were found at the interface of the riparian shelterbelt and the alfalfa field. The first one was located within the alfalfa field, 5 m from its edge, and it had three active openings in a Northern Pocket Gopher burrow system. The second den was located at the base of a rose (*Rosa* spp.) bush, in the grass-dominated riparian vegetation, 3 m from the edge of the alfalfa field. In 1999-2000, a Long-tailed Weasel was found within the same 8-ha area, with tracks leading to a den, in a coarse woody debris pile at the base of a large willow (Figure 1).

The male's movements encompassed an 18-ha area comprising approximately 1.2 km of the Vermilion River, and a continuous alfalfa field (Figure 2). Tracks led to consecutive holes in the river's bank, which may have been its den, near a Beaver (*Castor canadensis*) dam.

Straight-line movements

Straight-line movements were recorded in 1998-1999 when the female crossed from one side of the field to the other, at narrows (Figure 1). In 2000, a 43-m long straight-line movement into the field led to a digging site. The male crossed the field in a straight line to enter bush areas on either side of narrows, or to investigate the tracks of a smaller weasel (possibly *Mustela erminea*).

Sinuous movements

In 1998-1999, the female traveled in a sinuous way along the creek and the field's edge, investigating woody debris, ground openings, and boulders. Sinuous movements consisted of a series of zigzags with bends and turns approximately 30 cm on each side of an imaginary central line (Figure 3). Such movements were extensive along the field's edge and extended from one den to the other (Figure 1). In 2000, sinuous movements were recorded on the south side of the study area. The male Long-tailed Weasel also traveled all along the edges of the river and the field in a sinuous manner.

Arc movements

In November and December 1998, the female Long-tailed Weasel interrupted its continuous, sinuous movements along the riparian shelterbelt-field ecotone with pronounced arcs that extended into the alfalfa field (Figure 3). These arcs began and ended at the edge of the field. Seven arcs of various sizes were recorded (Figure 1). From the center of their base to the apex, they extended from 6 to 45 m into the field ($\bar{x}$ = 19.6 m, standard error = 5 m). The width at their base ranged from 0.6 to 28 m ($\bar{x}$ = 10.2 ± 4 m). Twenty-five Northern Pocket Gopher concentrations were found in the alfalfa field (Figure 1). Five (71%) of the seven Long-tailed Weasel arc movements overlapped Northern Pocket Gopher concentrations. Long-tailed Weasel tracks circled or crossed Northern Pocket Gopher mounds (Figure 4) and earth plugs (holes filled up with soil by pocket gophers returning from the surface to the underground tunnel of their burrow system).

Six male arc movements were recorded in 1998 (Figure 2). They extended from 5 to 52 m into the field ($\bar{x}$ = 14.8 ± 7.5 m). The width at their base ranged from 3 to 38 m ($\bar{x}$ = 12.5 ± 5.3 m). Three (50%) of the arc movements overlapped Northern Pocket Gopher burrow systems.

In 2000, 10 arc movements were recorded when tracking the Long-tailed Weasel in Study Area I (Figure 1). They extended from 6 to 20 m into the field (length $\bar{x}$: 11.2 ± 2 m; width $\bar{x}$: 6.8 ± 1 m). The Northern Pocket Gopher distribution had expanded considerably across the field since the previous year, and all arc movements overlapped burrow systems.

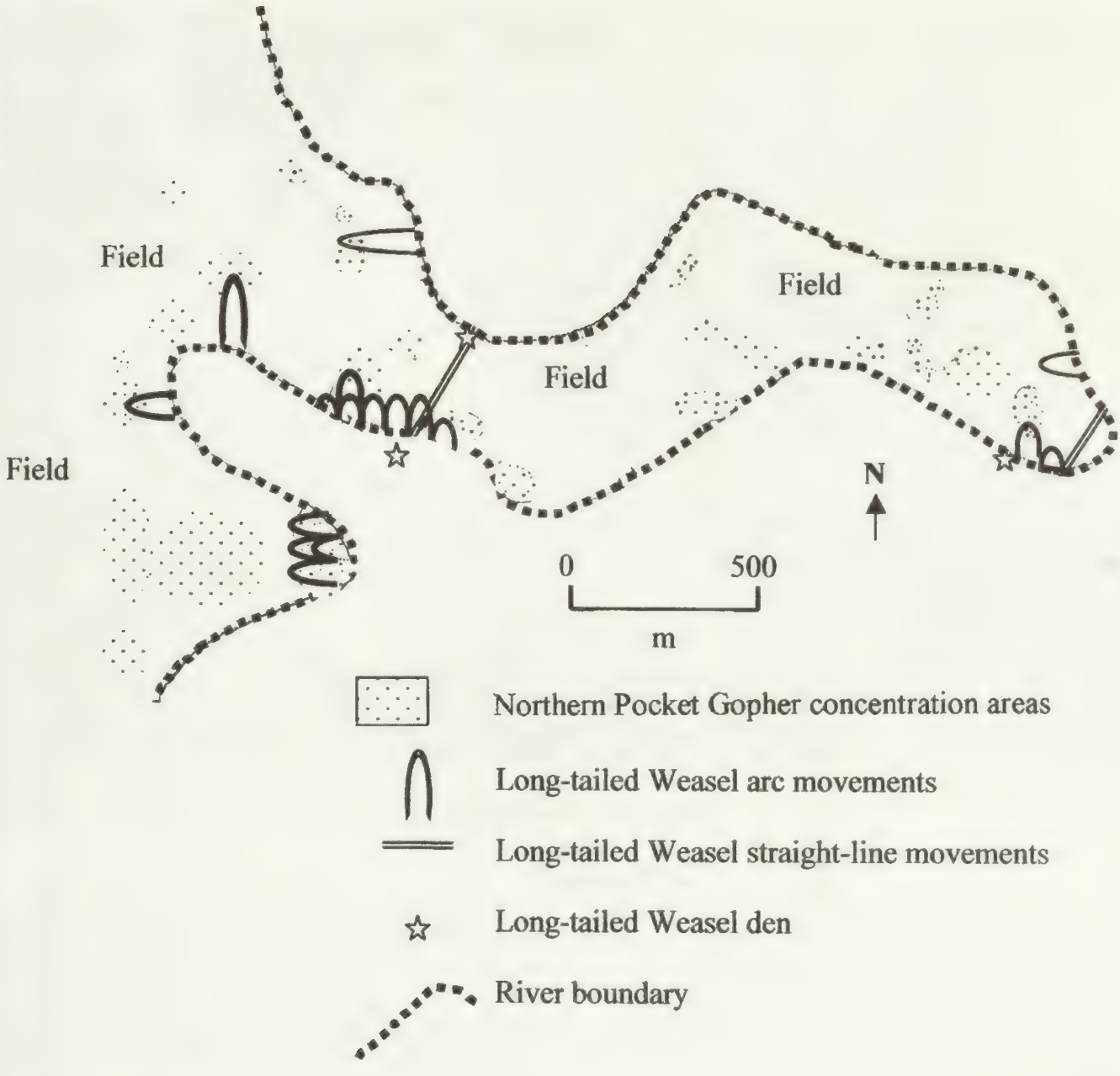

FIGURE 1. Dens and arc movements of Long-tailed Weasels in winters 1998-1999 and 2000 in Study Area I, Vermilion River, Vegreville, Alberta.

Diggings

Twenty fresh diggings by the female Long-tailed Weasel were flagged during the 1998 surveys, all in the alfalfa field and mostly along arc movements. Seventeen (85%) of them were in Northern Pocket Gopher burrow systems (Figure 4). The holes were still open when re-visited in April 1999.

Discussion

This study validated the hypothesis that Long-tailed Weasels investigated Northern Pocket Gopher burrow systems as they encountered them. However, encounters were not the result of random wanderings. Long-tailed Weasels left their line of travel along the field ecotone to enter the field and investigate it with arc movements of various lengths and widths that overlapped specific Northern Pocket Gopher concentrations. Peters (1978) and Powell (2000) suggested that carnivores had cognitive maps of where they live. Powell (1978, 1994) showed that the Fisher (*Martes pennanti*), another mustelid, did not use the space within its home range randomly. Powell documented cases where the Fisher crossed in straight-line areas of low prey availability, but spent more time investigating Porcupine (*Erethizon dorsatum*) winter dens. The arc movements recorded in this study suggest that Long-tailed Weasels also have a cognitive map of the distribution of potential preys. Long-tailed Weasel apparently directed their movements to active Northern Pocket Gopher burrow systems that they opened and entered. While Northern Pocket Gophers keep their burrow system closed from outside intruders (Witmer et al. 1999), the fact that the systems opened by the Long-tailed Weasels were not plugged back suggests that resident

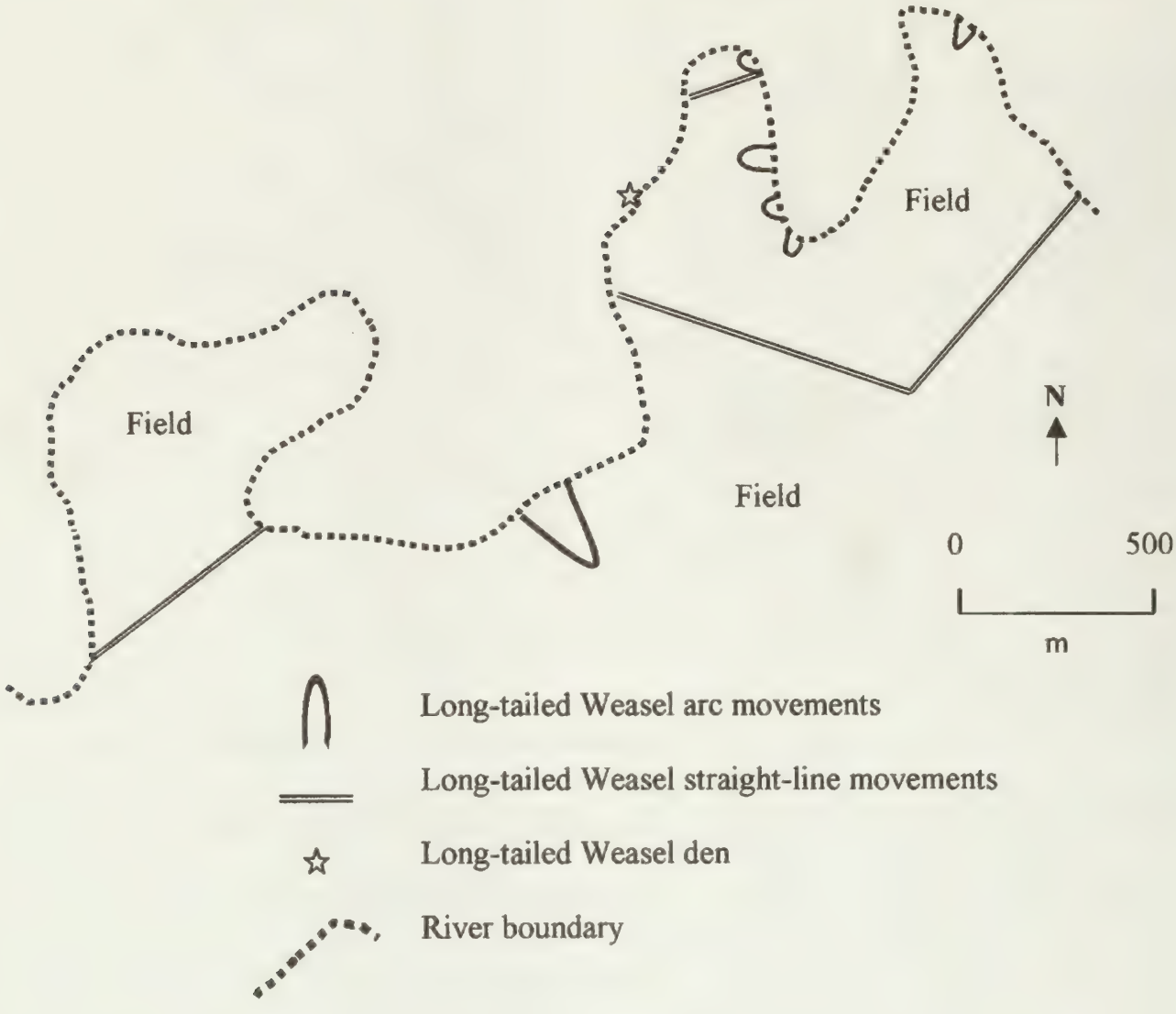

FIGURE 2. Arc movements and possible den of a male Long-tailed Weasel in winter1998-1999 in Study Area II, Vermilion River, Vegreville, Alberta.

Northern Pocket Gophers either abandoned their burrow system or more likely were killed by Long-tailed Weasels. Simms (1979) suggested that Long-tailed Weasels in western Canada preyed heavily on Northern Pocket Gophers. He estimated minimum passable tunnel diameter for average-sized male Long-tailed Weasels to be 4.3 cm, which is smaller than the minimum average diameter of 5.8 cm for tunnels of *Thomomys* spp. (Miller 1957; Bonar 1995*).

The sinuous movements of Long-tailed Weasels along riparian shelterbelts and field edges are in agreement with previous reports on the meandering nature of Long-tailed Weasel movements (Quick 1944; Wobeser 1966). Powell (1978) pointed out that weasel foraging behavior was characterized by frequent direction changes. Such movements would increase their chances to encounter small mammals, and might help avoiding predators (Powell 1978).

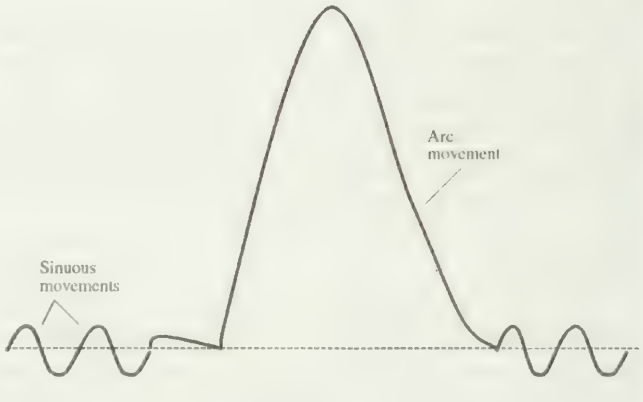

FIGURE 3. Schematic representation of Long-tailed Weasel sinuous and arc movements.

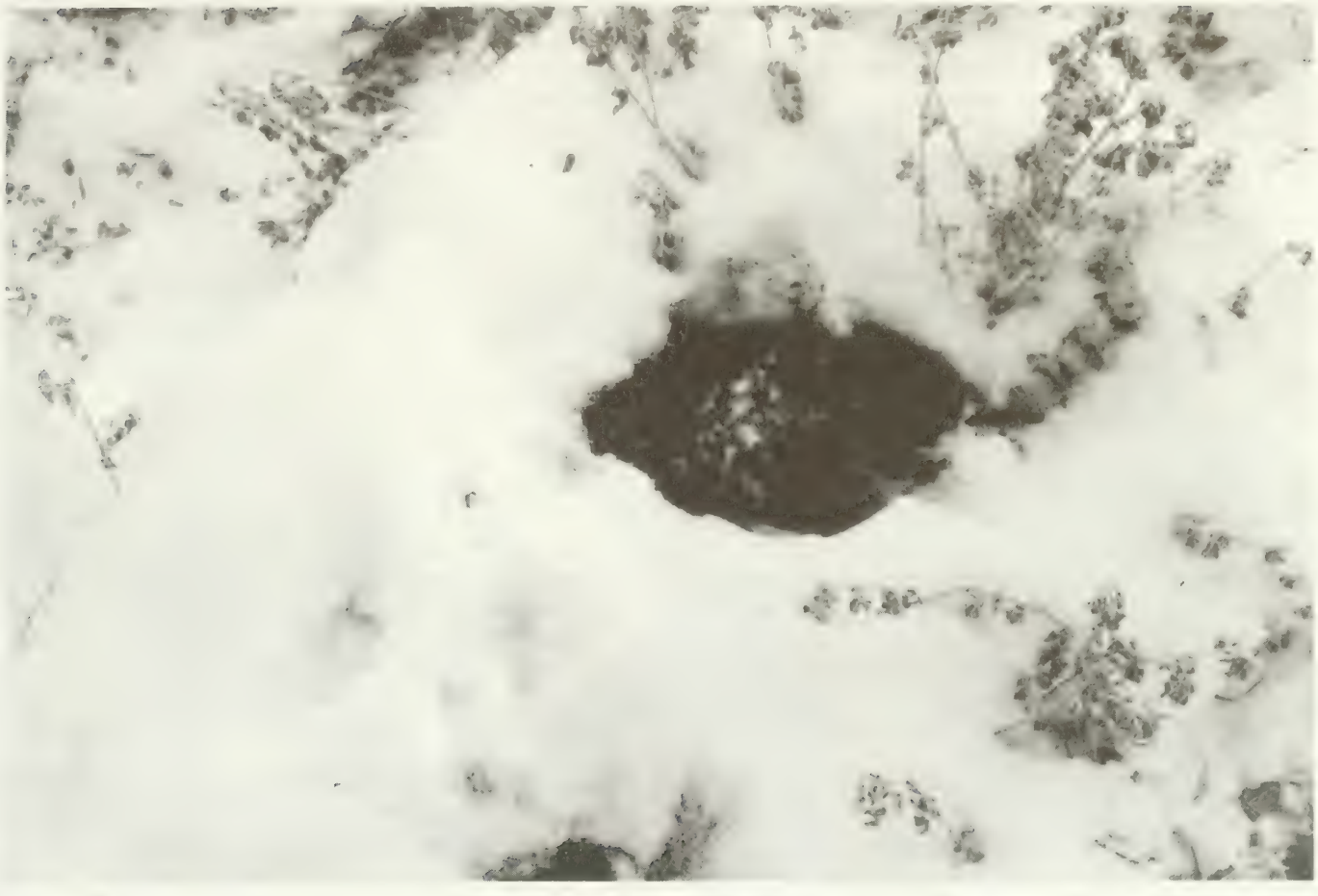

FIGURE 4. Snow-covered Northern Pocket Gopher mound opened (hole diameter: 5 cm) by a female Long-tailed Weasel in winter 1998-1999 in Study Area I, Vermilion River, Vegreville, Alberta.

Snowtracking is an advantageous technique as it allows one to study how Long-tailed Weasels use microenvironments. More snowtracking data should be gathered on Long-tailed Weasels in alfalfa fields to better understand their relationship with Northern Pocket Gophers. Unfortunately, the collection of such data is not an easy task. It is difficult to find alfalfa fields that are in proximity to water, and are inhabited by both species. On the other hand, a better understanding of the use of alfalfa fields and Northern Pocket Gopher populations by Long-tailed Weasels in a well-developed agricultural area such as central Alberta may be vital to ensure that this mustelid does not become threatened, as was feared a few decades ago (Gamble 1982*).

Acknowledgments

I am thankful to Alberta Conservation Association, Ducks Unlimited, and Red Deer River Naturalist Club for funding this project. I am grateful to C. Bohoychuk for allowing us to work on his land. I thank veterinarian Louis Kwantes, Park Veterinary Clinic in Sherwood Park, for anaesthetizing the female weasel, and Pamela J. Cole and Nicole A. Proulx for technical assistance. I thank Pauline Feldstein, Alpha Wildlife, and Roger A. Powell, North Carolina University, for reviewing an earlier version of this manuscript. This paper benefited from the comments of one anonymous reviewer and David Nagorsen.

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Received 9 January 2004
Accepted 14 March 2005

Long-tailed Duck, *Clangula hyemalis*, Eider, *Somateria* spp., and Scoter, *Melanitta* spp., Distributions in Central Alaska Beaufort Sea Lagoons, 1999–2002

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Noel, Lynn E., Stephen R. Johnson, and Gillian M. O'Doherty. 2005. Long-tailed Duck, *Clangula hyemalis*, eider, *Somateria* spp., and scoter, *Melanitta* spp., distributions in Central Alaska Beaufort Sea Lagoons, 1999-2002. Canadian Field-Naturalist 119(2): 181-185.

During July and August 1999–2002, distributions of Long-tailed Ducks (*Clangula hyemalis*), eiders (*Somateria* spp.) and scoters (*Melanitta* spp.) were documented in three barrier island-lagoon systems in the central Alaska Beaufort Sea. Concentration areas for each species were determined during 16 aerial surveys. Kernel density procedures were used to delineate 75% and 50% "activity" or concentration areas for all three species. Long-tailed Ducks were 13 times more numerous than eiders and 38 times more numerous than scoters. The Long-tailed Duck 75% activity area encompassed all three lagoon systems and was three times as large as the eider activity area and one-third larger than the scoter activity area. Eider activity areas were located only in the eastern lagoon, and scoter activity areas were located only in the western lagoon. Density contours showed patterns of repeated habitat use for sea ducks over the four years of sampling and improve our understanding of sea duck habitat use within Beaufort Sea barrier island-lagoon habitats.

Key Words: *Clangula hyemalis*, *Melanitta*, *Somateria,* molt, normal kernel density, Arctic, barrier island, Alaska.

Up to 30 000 molting waterfowl aggregate during mid-July through early September along the mainland and barrier island shorelines in the central Beaufort Sea, Alaska (Figure 1; Johnson et al. 2005). Since 1990, Long-tailed Ducks (*Clangula hyemalis*), the predominant waterfowl species in the central Alaska Beaufort Sea lagoon systems (Johnson and Gazey 1992), have shown a declining trend in total numbers during the male molt period in these lagoons (i.e., mid July to late August) (Fischer et al. 2002; Johnson et al. 2005). During 1999–2002, distributions of waterfowl in the barrier island-lagoon systems between Spy Island and Flaxman Island, Alaska, were documented (Figure 1). Normal kernel density contours, a smoothed density estimation function (Powell 2000), for the combined distributions are presented to delineate "activity" or concentration areas for Long-tailed Ducks, eiders and scoters within these lagoons.

Methods

Aerial Surveys

During each survey, the western lagoon, Stefansson Sound, and eastern lagoon subdivisions of the study area were surveyed on the same day (Figure 1; Johnson 1990; Johnson and Gazey 1992). Lagoon systems were surveyed in varying orders, but all transects within a lagoon system were surveyed before moving to the next lagoon system, and the entire survey area was flown within a 5-hour period. A total of 16 surveys totaling 59 hours was conducted over four years. Four surveys each were flown during 30 July to 26 August 1999 and 1 to 24 August 2000, three surveys were flown during 23 July to 11 August in 2001, and five surveys were flown during 20 July to 14 August 2002.

Aerial surveys were conducted in a single-engine fixed high-wing aircraft (Cessna 206) on floats. The survey crew consisted of a pilot and two observers. One observer sat in the right front seat and the other in the left rear seat. Survey altitude was approximately 45 m above ground level and ground speed was approximately 180 km/h. Transect width was 400 m total, 200 m on each side of the aircraft.

The surveys were during the peak of the male Long-tailed Duck molt (flightless) period from 15 July to 21 August (Johnson and Richardson 1981; Johnson 1985; Johnson and Gazey 1992). Because Long-tailed Ducks are known to concentrate along the barrier islands in the late afternoon and evening (Johnson and Richardson 1981; Johnson 1982, 1985), surveys were scheduled as late in the day as practical, generally from 14:00 to 19:00. Surveys on days with high winds (>35 km/h) were postponed until winds, wave height, and chop diminished, thereby improving the observers' ability to see birds on the water (Johnson 1990; Johnson and Gazey 1992).

Survey Data

Tape recorders were used to record all bird observations. Continuous audio-tape recordings included information on transects, observations, survey weather

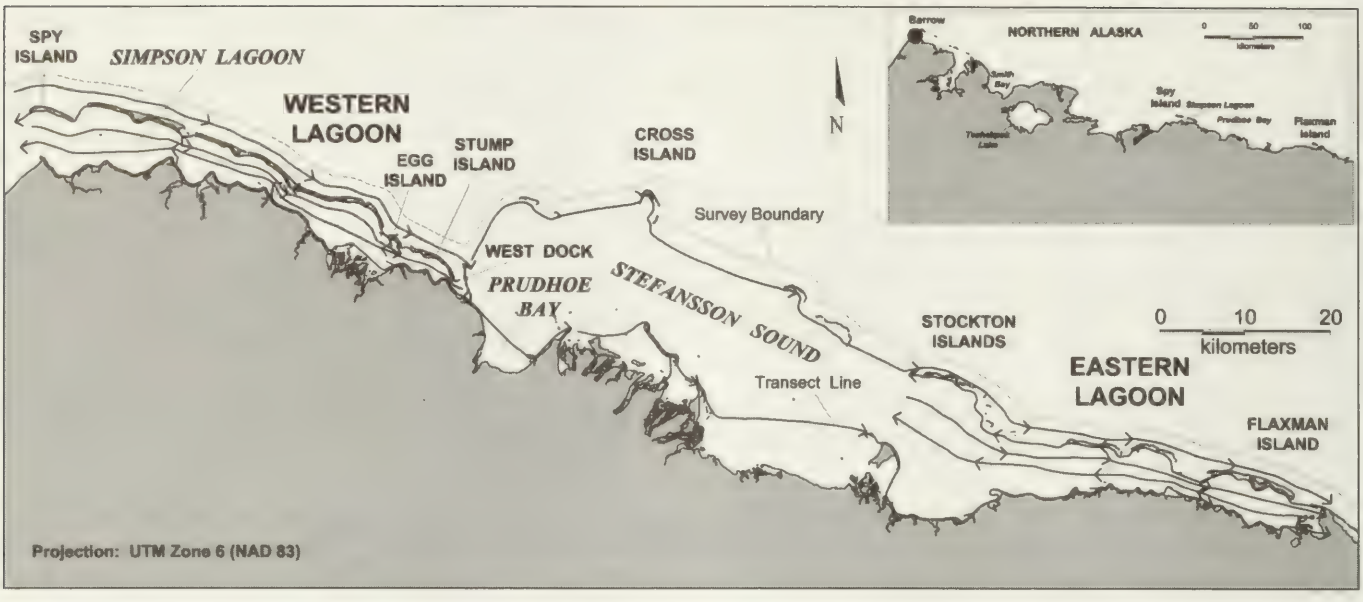

FIGURE 1. Location of aerial survey transects used to record Long-tailed Duck, eider and scoter distribution and abundance in the barrier island-lagoon systems between Spy Island and Flaxman Island, Alaska, July and August 1999–2002.

conditions, and 30-second intervals (time periods) marked by a timer. A notebook computer with mapping software linked to a Global Positioning System (GPS) receiver recorded the flight line at one-second intervals during surveys. Observers synchronized their watches with GPS satellite time, and these times (recorded for transects and time periods) were used to geo-reference survey data.

Normal Kernel Density Contours

Density contours were computed and mapped using the ArcView® (ESRI, 1996, Redlands, California) Animal Movement software extension (Hooge and Eichenlaub 1997*; Silverman 1986; Worton 1989; Seaman and Powell 1991*). "Activity" or concentration areas were represented by density contours delineating 75% and 50% of birds (Powell 2000). Computations were based on the total number of on-transect individuals summarized for each 30-second time-period over the entire survey area.

Density contours were calculated for Long-tailed Ducks, all eiders and all scoters. Most eiders (99% of eiders identified to species) were Common Eiders (*Somateria mollissima v-nigrum*) with very small numbers of King Eiders (*Somateria spectabilis*). Most scoters (98% of scoters identified to species) were Surf Scoters (*Melanitta perspicillata*) with small numbers of Black Scoters (*Melanitta nigra*) and White-winged Scoters (*Melanitta fusca*).

Results

Long-tailed Ducks were 13 times more numerous than eiders and 38 times more numerous than scoters (Table 1). The 75% activity area for Long-tailed Ducks included parts of survey areas in all three lagoon systems and was three times as large as the eider activity area and one-third larger than the scoter activity area (Figure 2, Table 1). The only eider activity area was in the eastern lagoon, and the only scoter activity area was in the western lagoon (Figure 2). The 50% contour area was about one-third to three-quarters of the size of the 75% contour area depending on the species (Figure 2, Table 1).

The eider activity area was used mainly by large flocks of molting males, and smaller groups (<10 birds) of resting females and females with broods aggregated along barrier-island or mainland shorelines. Scoters occurred in scattered mixed feeding flocks with Long-tailed Ducks in mid-lagoon habitats in the western lagoon. Eider and scoter activity areas did not overlap (Figure 2).

TABLE 1. Activity area size (km^2), total bird density (number per km^2) and total number of Long-tailed Ducks, eiders, and scoters during July and August 1999–2002 in the barrier island-lagoon systems between Spy Island and Flaxman Island, Alaska.

	Total birds 16 surveys	75% activity area km^2	Density Number per km^2	50% activity area km^2	Density Number per km^2
Long-tailed Ducks	181224	642	243	238	388
Eiders	13708	225	38	97	54
Scoters	4762	423	10	318	13

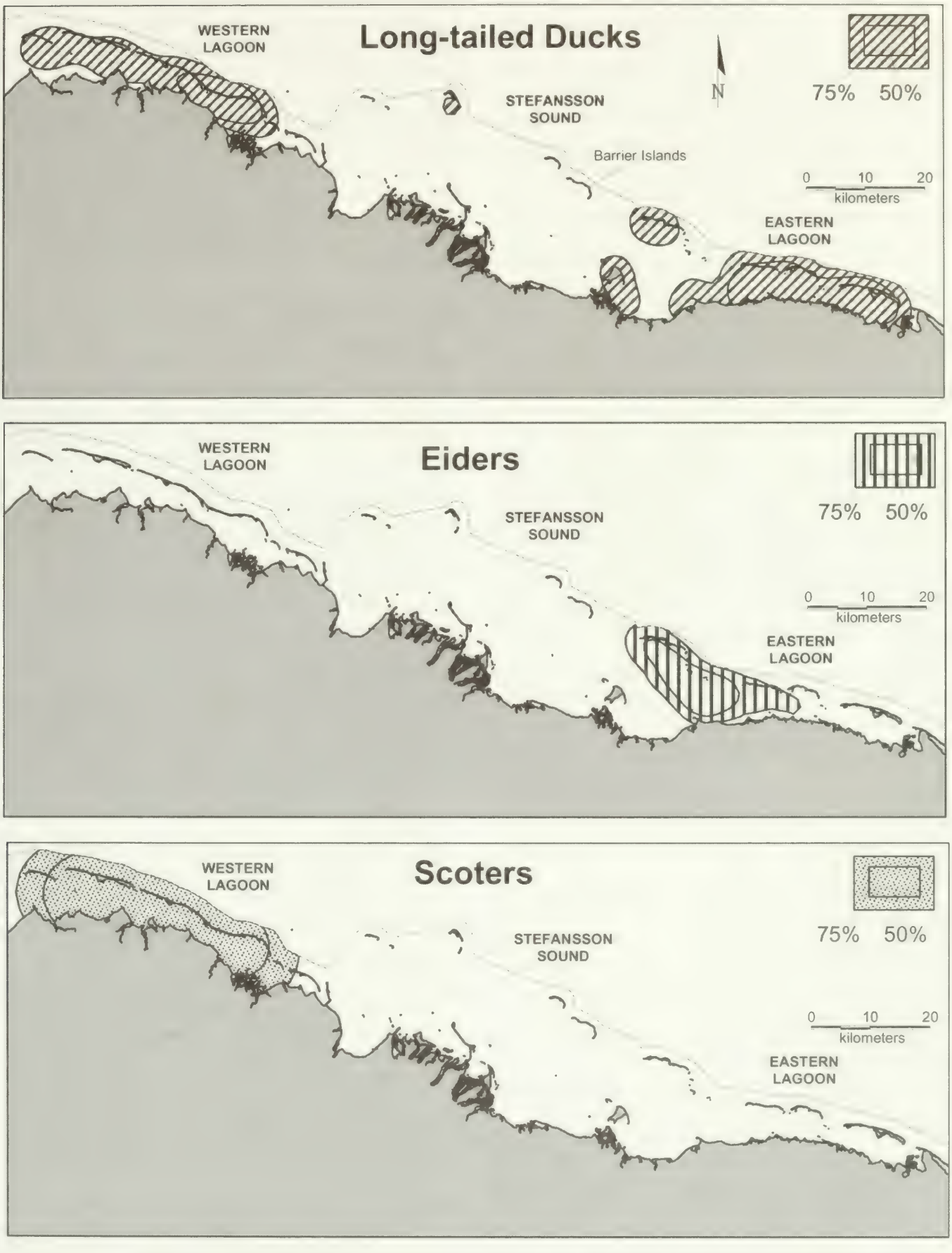

FIGURE 2. Long-tailed Duck, eider and scoter activity areas for 75% and 50% of total birds during July and August 1999–2002 in the barrier island-lagoon systems between Spy Island and Flaxman Island, Alaska.

Discussion

Long-tailed Duck distributions in barrier island-lagoon systems reflected proximity to both lagoon foraging habitats and resting habitats along the barrier island and mainland shorelines (Johnson 1990; Johnson and Gazey 1992; Johnson et al. 2005). Eiders and scoters both were more limited in their distributions than Long-tailed Ducks (Figure 2). Eider activity area was limited to the eastern lagoon, while scoter activity area was within the western lagoon (Figure 2). Eider distributions reflected foraging, nesting and resting habitat use, but scoter distributions reflected only foraging and resting habitat use. Only the Long-tailed Duck 75% activity area included the Stefansson Sound subdivision of the study area.

Long-tailed Ducks are less specific in their prey selection than are either eiders or scoters (Nilsson 1972; Stott and Olson 1973, Sanger and Jones 1984). Long-tailed Duck prey may be either nektonic or benthic (Johnson 1984; Stott and Olson 1973). In the Simpson Lagoon area, preferred prey are crustaceans and bivalves in 2–3 m water depths, where prey densities are highest (Johnson 1984). Given the less specific nature in their foraging, and observations of mixed-species foraging flocks of Surf Scoters and Long-tailed Ducks in the western lagoon, competition and mutual exclusion between Long-tailed Ducks and scoters is unlikely.

Eiders are primarily benthic feeders and, although they may be more specific in their food habits than Long-tailed Ducks, they are more general than scoters (McGilvrey 1967; Stott and Olson 1973; Cantin et al. 1974; Vermeer 1981). The eider activity area in the eastern lagoon encompassed the deeper waters (up to 6 m), with crustacean and bivalve prey (Woodward-Clyde Consultants 1996*) known to be preferred by this species (Nilsson 1972).

Aggregations of eiders are often associated with breeding habitats (Savard et al. 1999). Common Eider nesting activities in our study area are concentrated on the Stockton Islands in the eastern lagoon system and on Egg and Stump islands in the western lagoon system (Figure 1; Johnson 2000). The 50% eider activity contour in our study included the Stockton Island group; however, the center of this activity area was directly associated with the larger foraging flocks of eiders, not with known nesting areas (Figure 2).

There was no overlap in activity areas for eiders and scoters (Figure 2). Although some of the same foods are preferred by these two species, different foraging habitats were selected. The lack of overlap between eider and scoter activity areas may reflect differential habitat use similar to that described elsewhere (Savard et al. 1999). Scoter distributions are known to be associated with foraging habitats rich in bivalves (Nilsson 1972; Vermeer 1981). Although bivalves are known to occur throughout the barrier island-lagoon systems in the Alaska Beaufort Sea, fine-scale prey sampling across all known feeding habitats has not yet occurred.

Direct links between sea duck distribution and prey availability in Beaufort Sea barrier island-lagoon habitats have only been documented in a few studies (Johnson and Richardson 1981; Johnson 1984). Nevertheless, this study and others (Johnson et al. 2005) show strong patterns of repeated use of discrete lagoon habitats by sea ducks. These patterns are likely linked to food availability during the mid-summer molt period. This information will be helpful when designing sea duck mitigation and monitoring programs as development occurs in barrier island-lagoon habitats in the Alaska Beaufort Sea.

Acknowledgments

Preparation of this manuscript and field studies were funded by BP Exploration (Alaska) Inc. (BP) and the Point Thomson Unit Owners (BP, ExxonMobil Production Company, Conoco Phillips Alaska, Inc. and others). W. Streever, D. Trudgen, A. Erickson, and W. Cullor, BP Environmental Studies Group, provided suggestions concerning this study and assistance with logistical arrangements. W. Streever, BP Environmental Studies Group Leader, and G. Robilliard, ENTRIX, Inc. provided comments that improved this manuscript. J. Helmericks piloted the survey aircraft. In addition to the authors, T. Olson, I. Helmericks, R. Rodrigues, and M. Bentley served as observers.

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Received 26 May 2004
Accepted 11 March 2005

Winter Habitat Use by Moose, *Alces alces*, in Central Interior British Columbia

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Proulx, Gilbert, and Rhonda M. Kariz. 2005. Winter habitat use by Moose, *Alces alces*, in central interior British Columbia. Canadian Field-Naturalist 119(2): 186-191.

In central British Columbia, recent epidemics of Mountain Pine Beetle (*Dendroctonus ponderosae*) have resulted in the use of expansive clearcut areas to remove infested mature and old Lodgepole Pine (*Pinus contorta*) stands. This study aimed to determine if Moose (*Alces alces*) use late-successional Lodgepole Pine stands in mid- to late-winter. Moose activity and habitat use was determined during February-March track surveys in 2000 (60 km) and 2001 (55.7 km). In 2000 (69 tracks) and 2001 (313 tracks), Moose track distribution differed significantly ($P < 0.05$) from random. They were significantly more abundant than predicted in young stands (dominated by *Picea* spp.), or early seral stages; they were less abundant than predicted in mature and old Lodgepole Pine stands. It is unlikely that harvesting late-successional Lodgepole Pine stands would affect Moose winter habitat supply.

Key Words: *Alces alces*, Moose, snowtracking, Lodgepole Pine, *Pinus contorta,* British Columbia.

Most work suggests that a proper interspersion of food and shelter in winter can be an important and possibly limiting feature of Moose (*Alces alces*) habitat (Welsh et al. 1980; Proulx and Joyal 1981; Peek et al. 1987). Timber harvesting may have a positive effect on Moose by creating early seral stages rich in browse. On the other hand, it may be detrimental to Moose, particularly in winter, if a mosaic of varied cover types and regeneration sites is not properly maintained (Telfer 1970).

In central British Columbia, recent epidemics of Mountain Pine Beetle (*Dendroctonus ponderosae*) have resulted in the infestation of at least 4.2 million hectares of mature and old Lodgepole Pine (*Pinus contorta*) stands (generally > 80 years), and the use of expansive clearcut silviculture programs to recover the timber (Readshaw 2003*). Moose is a species highly valued by local residents and native groups, and the B.C. Ministries of Forests and Water, Lands, and Air Protection voiced their concerns regarding the removal of Lodgepole Pine cover and the possible reduction in Moose winter habitat.

This study aimed to determine if Moose used late-successional Lodgepole Pine stands in mid- to late-winter, when relatively deep snow and low temperatures force animals to seek canopy cover with well-developed understories (Thompson and Stewart 1997). Because late-successional pine stands do not usually offer a multi-storied cover and a well-developed understory, we hypothesized that Moose would make little use of late-successional lodgepole pine.

Study Area

The study area was located near Burns Lake (54°14'N, 125°46'W), in central British Columbia, 350 km west of Prince George. It encompassed an 80 km^2 area that is part of the Sub-Boreal Spruce Biogeoclimatic (SBS) Zone (Meidinger and Pojar 1991). The climate of the SBS zone is continental, and is characterized by seasonal extremes of temperatures, i.e., severe winters and relatively warm, moist, and short summers (Meidinger et al. 1991). The SBS is part of the Canadian Boreal Forest Region (Krajina 1965). Upland coniferous forests dominate the sub-boreal landscape. Hybrid White Spruce (*Picea engelmanii* × *glauca*) and subalpine fir (*Abies lasiocarpa*) are the dominant climax tree species. Lodgepole Pine is common in mature forests in the drier parts of the zone, and both Lodgepole Pine and Trembling Aspen (*Populus tremuloides*) pioneer the extensive early-seral stands (Meidinger et al. 1991). Wetlands are common and dot the landscape in poorly drained, postglacial depressions or river ox-bows. Wetland community types include sedge (*Carex* spp.) marshes, and fens with birch (*Betula* spp.), willows (*Salix* spp.), Black Spruce (*Picea mariana*), and hybrid spruce (*P. glauca* × *P. mariana)* (Meidinger et al. 1991).

Winter was generally harsher in 2000 than in 2001. In February, *in situ* data collections indicated that temperatures ranged from -28 to 2°C in 2000. They ranged from -24 to 9°C in 2001, but most days were between -4 and 0°C. During both years, surface conditions consisted of loose granular snow without crust, and hooves of Moose penetrated deeply into the snow. Mean snow depths of most habitats were significantly greater in 2000 than in 2001; on average, mean snow accumulation was 11.7 cm deeper in 2000 than in 2001 (Proulx and Kariz 2001*). In February 2000, mean snow depths approximated 43 cm in coniferous forests and 62 cm in openings/immature stands. In 2001, they averaged 33 and 52 cm in the same respective habitats.

Methods

Track surveys

Moose activity and habitat use was determined during two consecutive surveys each year: from 4-11 February and 24 February-1 March, 2000, and 30 January-5 February and 1-6 March, 2001. Each survey consisted of seven line transects crossing the study area. The same transects were used during both years, with some deviations due to open water in 2001. Transect lengths also varied within and between years due to accessibility (e.g., extensive, recent blowdowns interfered with researchers' movements) and environmental conditions (e.g., sudden change of weather with heavy snowfall); they ranged from 3.6 to 5.4 km, and were oriented to avoid paralleling roads (Cairns and Telfer 1980). They were plotted on forestry maps, and starting points were tied by compass bearings and distance to distinctive topographic features. Transects were snowshoed using a compass and 1:20 000 forestry maps; linear distance along a survey transect was determined with a hip chain and recorded each time there was a change of habitat type. Because the study focused on assessing the use of pine stands by Moose, habitat classification was kept simple, and limited to four types based on the British Columbia Resources Inventory Committee's (1998*) classes (Table 1).

Because Moose may take advantage of packed snowshoe trails in their daily movements (E. Telfer, Canadian Wildlife Service, personal communication), different transects were used from one survey period to the other during a same year. Each year, transects of the second survey period were placed in between those of the first survey. In winter, Moose usually move <1 km during their daily wanderings (Phillips et al. 1973; Hundertmark 1997) and, in order to avoid problems associated with pseudoreplication (Hurlbert 1984), transects of a same survey period were located at least 1 km apart. Therefore, tracks encountered in different transects during a survey period were likely from different animals. Along transects, because it was not possible to consistently determine if crossings were made by the same animal, all crossings were tallied (Raphael and Henry 1990*). Only fresh tracks were recorded.

Data analyses

All track transects were surveyed within one month, under similar weather conditions. Transects of the first and second surveys within a same year were pooled together for data analyses. Student *t*-test was used to compare mean numbers of tracks/transect between years. Pair-sampled *t*-testing was used to compare differences in the number of tracks recorded along a same transect from one year to the other (Zar 1999). Proportions of habitat classes traversed by survey transects were used to determine the expected frequency of track intersects per habitat class if tracks were distributed randomly with respect to habitat classes (Parker et al. 1981). Chi-square statistics with Yates correction (Zar 1999) were used to compare observed to expected frequencies of track intersects per habitat class. When chi-square analyses suggested an overall significant difference between the distribution of observed and expected frequencies, comparisons of observed to expected frequencies for each habitat class were conducted using a G-test for correlated proportions (Sokal and Rohlf 1981). Probability values ≤ 0.05 were considered statistically significant.

Results

Transects' vegetation composition

A total of 60 and 55.7 km were snowshoed in 2000 and 2001, respectively. Vegetation composition along transects was similar during both years (χ^2: 0.85, df: 5, $P > 0.05$) (Figure 1).

Frequency of Moose tracks/transect by year

On average, the number of Moose tracks/transect was significantly lower ($t = 4.79$, $P < 0.05$) in 2000 (n: 14 transects, $\bar{x} = 4.9$ tracks, standard deviation = 4.2 tracks) than in 2001 (n: 14, $\bar{x} = 22.3 \pm 12.9$ tracks). The number of tracks/transect ranged from 0 to 17 in 2000, and from 4 to 46 in 2001. Differences observed in the number of tracks recorded along a same transect from one year to the other were highly significant ($t = 5.16$, $P < 0.001$).

Frequency of Moose tracks per habitat type

In 2000, 69 fresh Moose tracks were encountered. The observed frequency of tracks per habitat class was significantly different ($\chi^2 = 23.62$, df: 5, $P = 0.001$; Figure 2) from a random distribution of tracks among habitat classes. Tracks were significantly more abundant than predicted in young stands (G = 4.19, df: 1, $P < 0.05$) (Figure 2). They were less abundant than predicted in late-successional pine stands (G = 8.21, df: 1, $P < 0.01$) (Figure 2).

In 2001, 313 fresh Moose tracks were encountered. The observed frequency of tracks per habitat class was significantly different ($\chi^2 = 81.06$, df: 5, $P < 0.001$; Figure 3) from a random distribution of tracks among habitat classes. Tracks were significantly more abundant than predicted in openings and immature 1 stands (G = 7.83, df: 1, $P < 0.01$), and in immature 2, scrub and pole stands (G = 3.85, df: 1, $P < 0.05$). They were less abundant than predicted in late-successional pine stands (G = 35.12, df: 1, $P < 0.001$) (Figure 3).

Discussion

During the cold winter of 2000 and the warmer winter of 2001, this study validated our expectation that Moose make little use of late-successional Lodgepole Pine in mid- to late-winter. The low use of late-successional pine stands may be explained by a generally poor understory with few deciduous shrubs for browse, and the lack of a multi-storied vertical cover (Raphael et al. 1992*).

During the two winters, Moose used a mosaic of habitat patches that offered deciduous shrubs for food and coniferous canopy for shelter. However, habitat

TABLE 1. Habitat types used in the study of Moose habitat use in February-March 2000 and 2001 in central British Columbia (after British Columbia Resources Inventory Committee's (1998) classes).

Forest type	Characteristics
Deciduous	Crown closure ≥ 10%, deciduous species > 75%
Coniferous	Crown closure ≥ 10%, coniferous species > 75%
– Pure	When ≥ 80% of the coniferous cover is provided by one species.
– Mixed	When the coniferous cover is provided by more than one species, neither species ≥ 80%
Coniferous-deciduous	Crown closure ≥ 10%, neither type > 75%
Habitat type	**Description**
Openings and immature 1 stands	0-10 years old. Open areas with sparse shrubs, and replanted clearcuts with trees < 2 m high.
Immature 2, pole, and scrub	11-40 years old. Immature 2 stands represent new forests following a natural or anthropogenic disturbance, with trees ≥ 2 m high. Pole stands are thick stands of trees (7.5 to 12.4 cm diameter at breast height), usually with little understory. Trees compete with one another and other plants for light, water, nutrients, and space to the point where most other vegetation and many trees become suppressed and die. Scrubs are typical lowlands and bogs with short Black Spruce and/or willow or alder thickets.
Young	40-80 year-old forests consisting mainly of spruce-dominated stands. Achievement of dominance by some trees and death of other trees leads to reduced competition that allows understory plants to become established. The forest canopy has begun differentiation into distinct layers. Vigorous growth and a more open and multi-storied stand than in the pole stage.
Late successional	≥ 81 years old forests consisting mostly of mature stands with even canopy of trees, with or without coarse woody debris down and leaning logs. A few old stands with tall and large canopy trees, canopy gaps, large snags, large downed woody debris, and developed understories. A second cycle of shade tolerant trees may have become established. Multi-layered canopy and developed understories usually missing in late-successional pine stands.

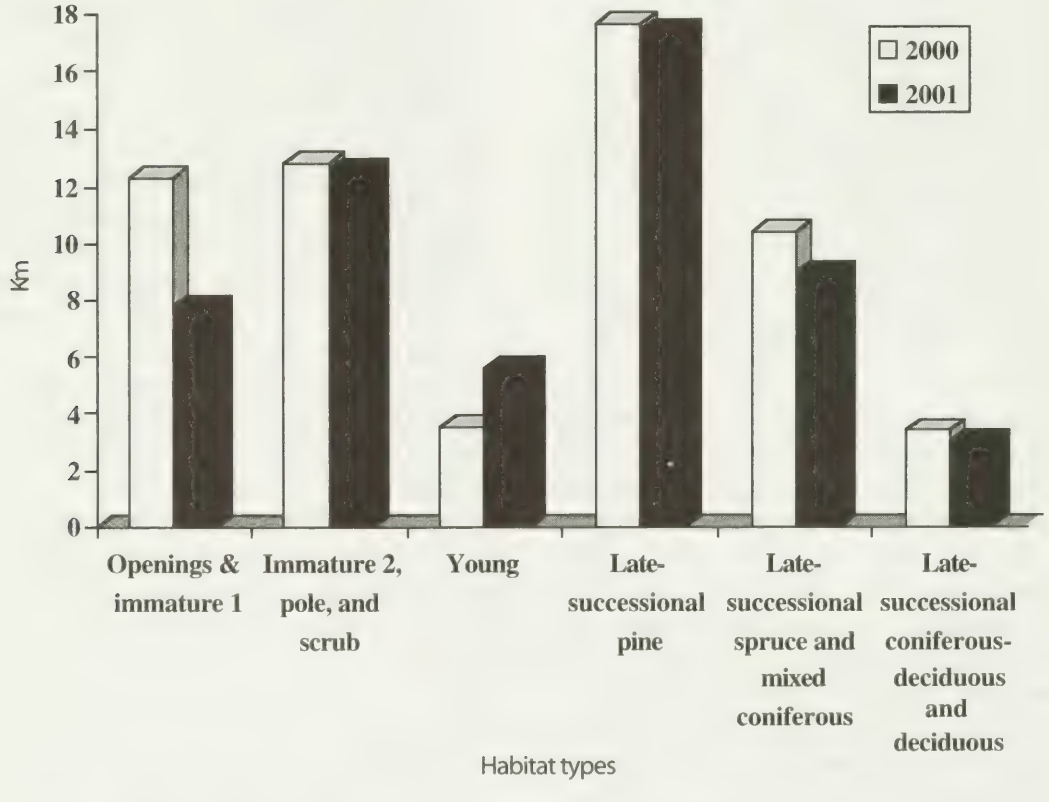

FIGURE 1. Distance traveled through each habitat type during Moose track surveys in central British Columbia, in February-March 2000 and 2001.

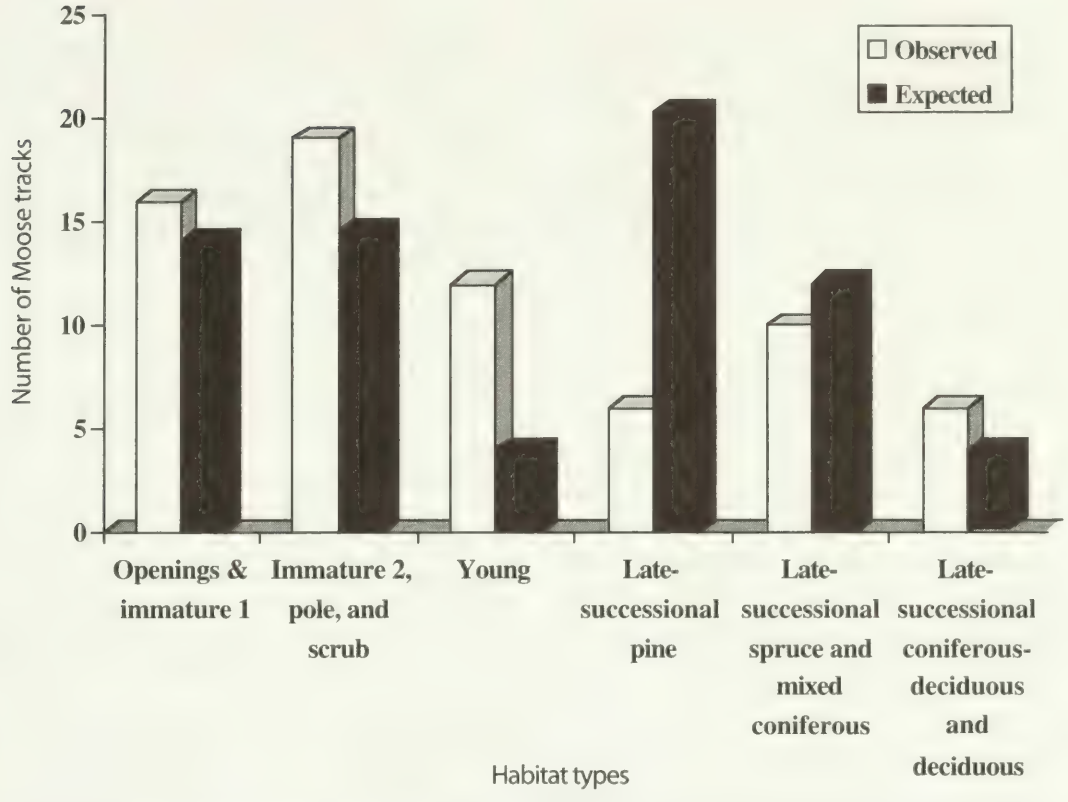

FIGURE 2. Observed and expected number of Moose tracks per habitat type in central British Columbia, February-March 2000.

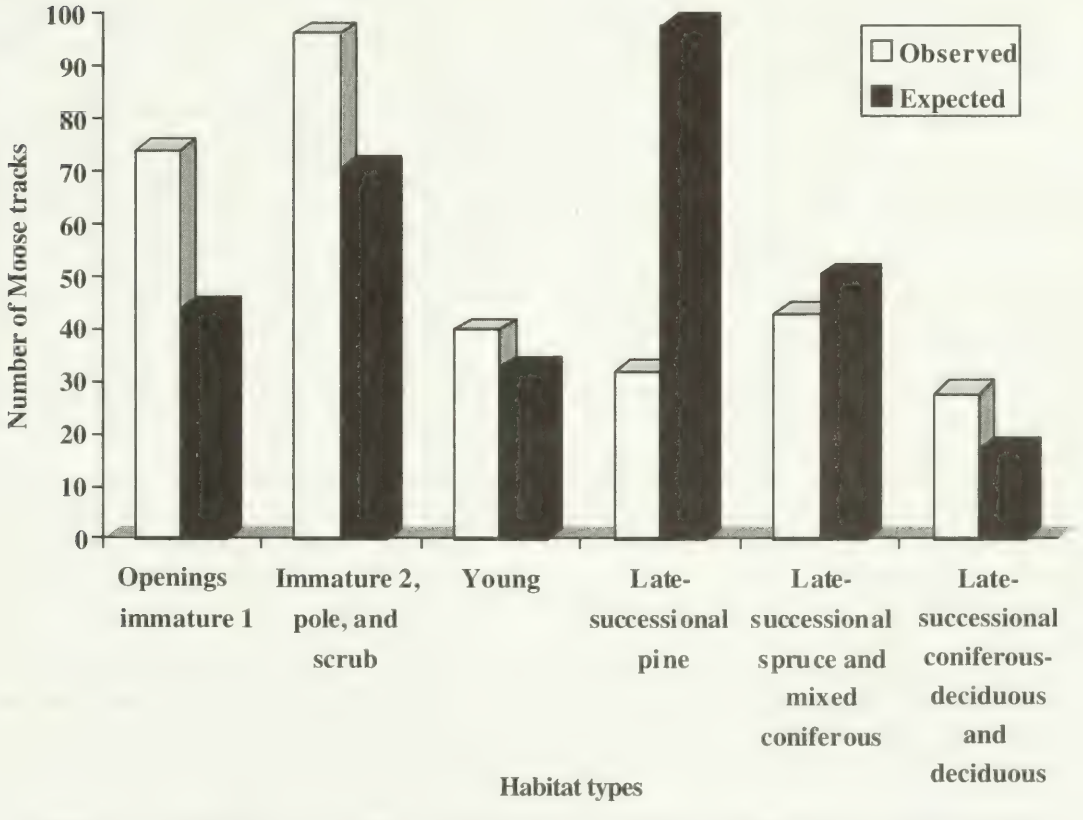

FIGURE 3. Observed and expected number of Moose tracks per habitat type in central British Columbia, February-March 2001.

mosaics used by Moose varied in composition between years. Moose were less active in 2000 than in 2001, as suggested by the markedly lower number of recorded tracks. In February-March 2000, Moose tracks were found in a variety of young and mature stands. Moose apparently sought habitats that offered both cover and food. The use of such habitats may occur with relatively shallow snow (Sandegren et al. 1985; Hundertmark 1997) and low temperatures (Schwartz and Renecker 1997), and has been reported

in many regions (Stevens 1970; Eastman 1974; Rolley and Keith 1980). In February-March 2001, Moose tracks were more abundant than predicted on the basis of a random distribution in openings with vegetation, immature stands and scrub. Moose can experience heat stress in winter when temperatures rise above –5°C (Schwartz and Renecker 1997); they may have used these habitats because they are rich in browse, but are also more open, windier, and cooler than forests (Renecker and Schwartz 1997).

It is unlikely that harvesting late-successional lodgepole pine stands to address Mountain Pine Beetle infestations would impact on Moose winter habitat supply. However, Moose may use pine stands to travel between wetlands and young forests, and cross clearcuts (Proulx, personal observation). Then, if pine stands are retained as connectivity corridors across the landscape, non-clearcut silviculture treatments may be warranted to sanitize beetle-infested stands and provide traveling Moose with protective cover.

Acknowledgments

We thank the British Columbia Ministries of Environment, and Water, Land and Air Protection for inquiring about Moose winter habitat, and Canadian Forest Products Ltd. (Canfor), Houston Operations, for funding the study. We thank Carl Vandermark, Canfor, for his interest in this study, and Joel Nicholson for technical help. We thank two anonymous referees for their valuable comments.

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Received 24 November 2003
Accepted 14 March 2005

Facts from Faeces: Prey Remains in Wolf, *Canis lupus*, Faeces Revise Occurrence Records for Mammals of British Columbia's Coastal Archipelago

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Price, Michael H. H., Chris T. Darimont, Neville N. Winchester, and Paul C. Paquet. 2005. Facts from faeces: prey remains in Wolf, *Canis lupus,* faeces revise occurrence records for mammals of British Columbia's coastal archipelago. Canadian Field-Naturalist 119(2): 192-196.

Archipelagos often harbour taxa that are endemic and vulnerable to disturbance. Conservation planning and research for these areas depend fundamentally on accurate and current taxonomic inventories. Although basic ecological information is in its infancy, the temperate rainforest islands of coastal British Columbia are undergoing rapid human-caused modification, particularly logging. We report herein new mammal records for these islands as determined by prey remains in the faeces of Wolves (*Canis lupus*), the area's apex mammalian terrestrial predator. Of particular interest is our detection of Marten (*Martes americana*) on islands previously inventoried and island occupancy by Moose (*Alces alces*), which have apparently migrated recently to coastal British Columbia. Remains in faeces provided valuable new species occurrence information, but more extensive and focused inventories are required to generate predictions of island occupancy by mammals based on biotic and abiotic landscape features.

Key Words: Wolves, *Canis lupus,* conservation, distribution, faeces, inventories, islands, mammals, archipelago, British Columbia.

Oceanic archipelagos often harbour taxa that are endemic, highly vulnerable to disturbance, and prone to extinction (Burkey 1995; Alcover et al. 1998). Sensible land-use planning often is constrained by a paucity of data on the distribution and abundance of organisms (Soulé and Kohm 1989), which may be particularly severe on islands. Biotic inventories provide critical information for conservation planning but frequently are not conducted because of time, financial, or other constraints (Kremen 1994). Due to accelerating rates of habitat loss, species inventories may be the foundation by which to measure the extent of human influences on extinction-prone biotas (Cook et al. 2001). Conversely, in poorly studied systems facing imminent disturbance, inventories may instigate timely conservation strategies and identify important areas for conservation research.

The numerous islands constituting British Columbia's coastal archipelago are nearly pristine yet face increasing pressure from development, particularly logging (Darimont and Paquet 2000*, 2002). Although earlier distribution reports have been valuable (McCabe and Cowen 1945; Cowen and Guiguet 1975; Craig 1990*, Nagorsen 1990), a paucity of fundamental ecological information still remains (such as complete mammal community records) for British Columbia's islands. In contrast, mammalian distribution on the adjacent Alexander Archipelago of Southeast Alaska has been well described (MacDonald and Cook 1996) and notable patterns of biogeography (e.g., Conroy et al 1999) and endemism (e.g., Cook and MacDonald 2001; Fleming and Cook 2002; Small et al. 2003) have emerged.

Accounts of mammal occurrence on islands are not always systematic but often dynamic, reflecting iterative coalescence of various collection records, accounts, and personal observations (e.g., MacDonald and Cook 1996). We extend this process here by benefiting from the foraging habits of coastal British Columbia's apex mammalian predator, the Wolf (*Canis lupus*), which has a wide potential niche.

During summers 2000 and 2001, we collected Wolf faeces along British Columbia's coast between the Kshwan Valley (55°37'N, 129°48'W) in the north and the Koeye River (51°46'N, 127°53'W) in the south (Figure 1). Our study area and sampling procedures are well described elsewhere (Darimont and Paquet 2000*, 2002; Darimont et al. 2004). Herein we identify mammalian prey occurring in faeces collected on islands only. We compared hair in faeces with voucher samples and also used dichotomous keys (Mathiak 1938; Mayer 1952; Stains 1958; Price 2003*). We compared these records of prey remains on islands with existing information regarding mammal occurrence for the British Columbia archipelago (McCabe and Cowen 1945; Cowen and Guiguet 1975; Craig 1990*, Nagorsen 1990) and herein report differences.

Wolves may deposit faeces from prey items consumed on other landmasses, but we consider this potential bias negligible. Although not well described, esti-

FIGURE 1. Study area and islands surveyed for mammal occurrence in British Columbia's coastal archipelago during summers 2000 and 2001.

mates of typical "gastric emptying times" in wild and captive wolves are rapid, ranging from 8 to 56 hours (Floyd et al. 1978; Weaver 1993; Kreeger et al. 1997; Peterson and Cuicci 2003). Weaver (1993) noted an average of four defecations/day in wolves fed *ad libitum*. Moreover, wolves typically rest after feeding and limit travel for several days thereafter (Mech 1966; Peterson 1977; Hayes et al. 2000; Peterson and Cuicci 2003). Finally, 65% of mammals we identified on each island were found in two or more scats.

TABLE 1. Mammal species identified in Wolf (*Canis lupus*) faeces collected on 29 islands in British Columbia's coastal archipelago during 2000 and 2001. Shown only are mammals not previously recorded in McCabe and Cowen (1945), Cowen and Guiguet (1975); Craig (1990*), or Nagorsen (1990). Species are as follows: Mule Deer (*Odocoileus hemionus sitkensis*); Pine Marten (*Martes americana*); Mink (*Mustela vison*); River Otter (*Lontra canadensis*); Weasel (*Mustela erminea*); Black Bear (*Ursus americanus*); Moose (*Alces alces*); Beaver (*Castor canadensis*). Sampling site codes match those in Figure 1. Islands previously inventoried for mammal occurrence indicated by asterisk.

Island	Area	Mammals Detected							
	(km^2)	Deer	Marten	Mink	R. Otter	Weasel	B. Bear	Moose	Beaver
1. Pearse	226	X	X		X		X		
2. Wales	97	X				X			
3. Dundas	160			X	X	X			X
4. Dunira	22					X			
5. Stephens	78								
6. Smith	51	X							
7. Lewis	7	X							
8. McCauley*	273								
9. Anger	51	X							
10. Banks*	1024		X						
11. Pitt*	1349							X	
12. Hawkesbury	322	X	X	X			X		X
13. Farrant	50	X	X						
14. Gribbell	207	X							X
15. Fin	13	X							
16. Dewdney	37	X			X				
17. Campania*	157								
18. Gil	238	X	X	X	X		X		
19. Princess Royal*	2295		X						
20. Moore*	5								
21. Aristazabal*	451		X						
22. Pooley	162	X	X	X		X	X		X
23. Roderick	239	X			X	X			
24. Chatfield*	48								
25. Cunningham	115	X							
26. Campbell	145								
27. Denny	127	X	X	X					
28. Goose*	24	X							
29. Hunter*	399								

Early distribution reports (above) collectively inventoried 10 of 29 islands surveyed in this study. Of particular note are our new accounts for Pine Marten (*Martes americana*) on Banks, Princess Royal, and Aristazabal Island (Figure 1), which previous studies did not detect. MacDonald and Cook (1996) reported (non-introduced) occupancy of Marten on nine Southeast Alaskan islands, adjacent to British Columbia's coast. Conroy et al. (1999) commented on their absence there from relatively small islands (< 232 km^2). In British Columbia, we identified Marten on four islands smaller than 232 km^2, including one as small as 50 km^2 (Table 1). These differences, however, may reflect island isolation (i.e., distance from other landmasses). Conroy et al. (1999) found that isolation (not size) best predicts species occurrence in coastal Alaska. Finally, the distributions of animals that are trapped commercially, such as Marten, may also reflect introductions and harvest pressure.

Also notable is the presence of Moose (*Alces alces*) on Pitt Island. Moose have not been reported previously on islands of British Columbia and are thought to range only in localised areas of major mainland rivers and the heads of inlets (Nagorsen 1990; Shackleton 1999; Blood 2000; but see Darimont et al. 2005). Mammals documented on islands not previously surveyed included other representatives of Cervidae and Mustelidae, as well as Ursidae and Castoridae (Table 1).

Data from faeces present potential biases and opportunity. One limitation, and a function of our limited sampling and the dietary niche of Wolves, is a lack of data on other taxa (e.g., Fisher, *Martes pennanti*), and especially smaller rodents. The Deer Mouse (*Peromyscus maniculatus*), for example, was absent from our samples. This species occurs on coastal islands and has been the subject of pioneering work on insularity in the region (McCabe and Cowen 1945), and continues to be a model organism elsewhere (e.g., Vucetich et al. 2001). Our "facts from faeces" approach, however, increases the breadth of valuable information available from analysing "waste" from animals (Putman 1984; Kohn and Wayne 1997).

New mammalian records for coastal British Columbia have scientific value and utility in conservation debate and land-use planning. As data accumulate, we hope to present a coherent explanation as to what biotic and abiotic conditions predict mammalian diversity on British Columbia's islands. Moreover, we agree wholeheartedly with MacDonald and Cook (1996) that, "the most distressing issue regarding our lack of knowledge for this vast area [coastal temperate rainforests] is that planners and policy makers are generating management decisions with great uncertainty. This is especially disconcerting given the accelerating rate of human-induced change occurring within the region's ecological systems".

Acknowledgments

This study took place in the Traditional Territories of several First Nation groups, from whom we sought permission before research began. We are extremely grateful to the Raincoast Conservation Society for financial and logistical support, field colleagues too numerous to acknowledge adequately, and skippers Stephen Anstee, Brian Falconer, Jean-Marc Leguerrier, and Dave Lutz. The McCaw Foundation, National Geographic Society, Vancouver Foundation, Wilburforce, World Wildlife Fund Canada, and private donors kindly provided funding. While preparing the manuscript, CTD was supported by a Natural Sciences and Engineering Research Council (NSERC) – Industrial Post-graduate Scholarship.

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Received 12 March 2004
Accepted 14 March 2005

Attempted Predation of a Child by a Gray Wolf, *Canis lupus*, near Icy Bay, Alaska

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On 26 April 2000 a six-year-old boy was attacked and repeatedly bitten by a Gray Wolf (*Canis lupus*) in a logging camp near Icy Bay, Alaska. The animal's behavior during the attack clearly contained elements of predation. The wolf was killed shortly after the attack and found to be in normal physical condition; tests for rabies and canine distemper were negative. Low densities of ungulate prey and increased energetic demands associated with denning may have influenced the wolf's behavior, but we believe the wolf's habituation to people was a more significant factor contributing to the attack. Food-conditioning may have facilitated the habituation process, but there was no evidence the attack resulted from a food-conditioned approach response.

Key Words: Gray Wolf, *Canis lupus*, food conditioning, habituation, predation, wolf aggression, wolf attack, Alaska.

Documented aggression by wild Gray Wolves (*Canis lupus*) toward humans in North America is rare and often characterized by bluff charges or brief attacks involving a single bite (Munthe and Hutchison 1978; Jenness 1985; Scott et al. 1985; Mech 1998; Strickland 1999; McNay 2002a, 2002b [Case 15, page 12]). However, in April 2000 near Icy Bay, Alaska, a wolf pursued and attacked a six-year-old boy, then attempted to carry the boy to nearby cover. The wolf inflicted 19 laceration and puncture wounds on the boy's back, legs, and buttocks before being driven away and killed. Among recent published accounts of wolf aggression toward humans in North America, none describe such persistent, aggressive behavior by a healthy wolf.

The Alaska Department of Public Safety (ADPS) conducted an investigation immediately following the attack. Later, we conducted a separate review of the incident. Details of the attack were obtained from our interviews with five people who either witnessed the attack or observed the wolf's behavior prior to the attack, and from the ADPS (2000*) report that included interviews with six additional people. We describe this uncommon incidence of wolf aggression and discuss possible motivations for the attack.

The Setting

The attack occurred at a logging camp near Icy Bay, Alaska (59°58'N, 141°39'W). The camp was in a 13 ha clearing surrounded by dense forest. It served 80 seasonal workers and seven permanent families. An unpaved road from a log sort yard on the shore of Icy Bay ran through the camp and continued westward. Gray Wolf habitat near Icy Bay is confined to about 100 km^2 of Sitka Spruce/Western Hemlock (*Picea sitchensis/Tsuga heterophylla*) forest surrounded by steep mountains, ice fields, and the Gulf of Alaska. A narrow corridor of forest along the beach leads to more suitable wolf habitat 50 km to the west (Figure 1).

The diet of Gray Wolves near Icy Bay probably contains a wide variety of foods. Moose (*Alces alces*) are migratory and no more than 20 are present at any time of the year. Mountain Goats (*Oreamnos americanus*) are found in steep terrain but are not often killed by wolves. Snowshoe Hares (*Lepus americanus*), Beaver (*Castor canadensis*), small rodents, and migratory birds are potential prey. Marine foods (fish, invertebrates, and marine mammals) are available as carrion on the beaches and Coho Salmon (*Oncorhynchus kisutch*) migrate into spawning creeks during late summer.

The Attack

About 9:00 a.m. on 26 April 2000, John Stenglein (age 6) and Keith Thompson (age 9) were playing in the forest edge on the camp's north perimeter. They heard a noise, looked up and saw a wolf standing 3 m away behind a low tree branch. The wolf showed its teeth and growled as it crouched under the branch toward them. The boys remained still until the wolf stepped forward and snarled again. John, wearing oversized boots, ran slowly and awkwardly. Keith ran ahead calling for help. Keith's dog, a male Labrador Retriever, was 50–100 m from the boys, but ran toward the wolf as the boys emerged from the forest (Figure 2).

John ran about 40 m across open gravel, then stumbled and fell. The dog briefly fought the wolf near the tree line, but the wolf disengaged and attacked John while the boy was on the ground. John struggled to escape, but the wolf lifted him off the ground, turned, and attempted to carry the boy toward the forest. Because of the boy's size (27 kg) and loose clothing, the wolf had difficulty carrying the boy and it began dragging John toward the tree line. Four adults res-

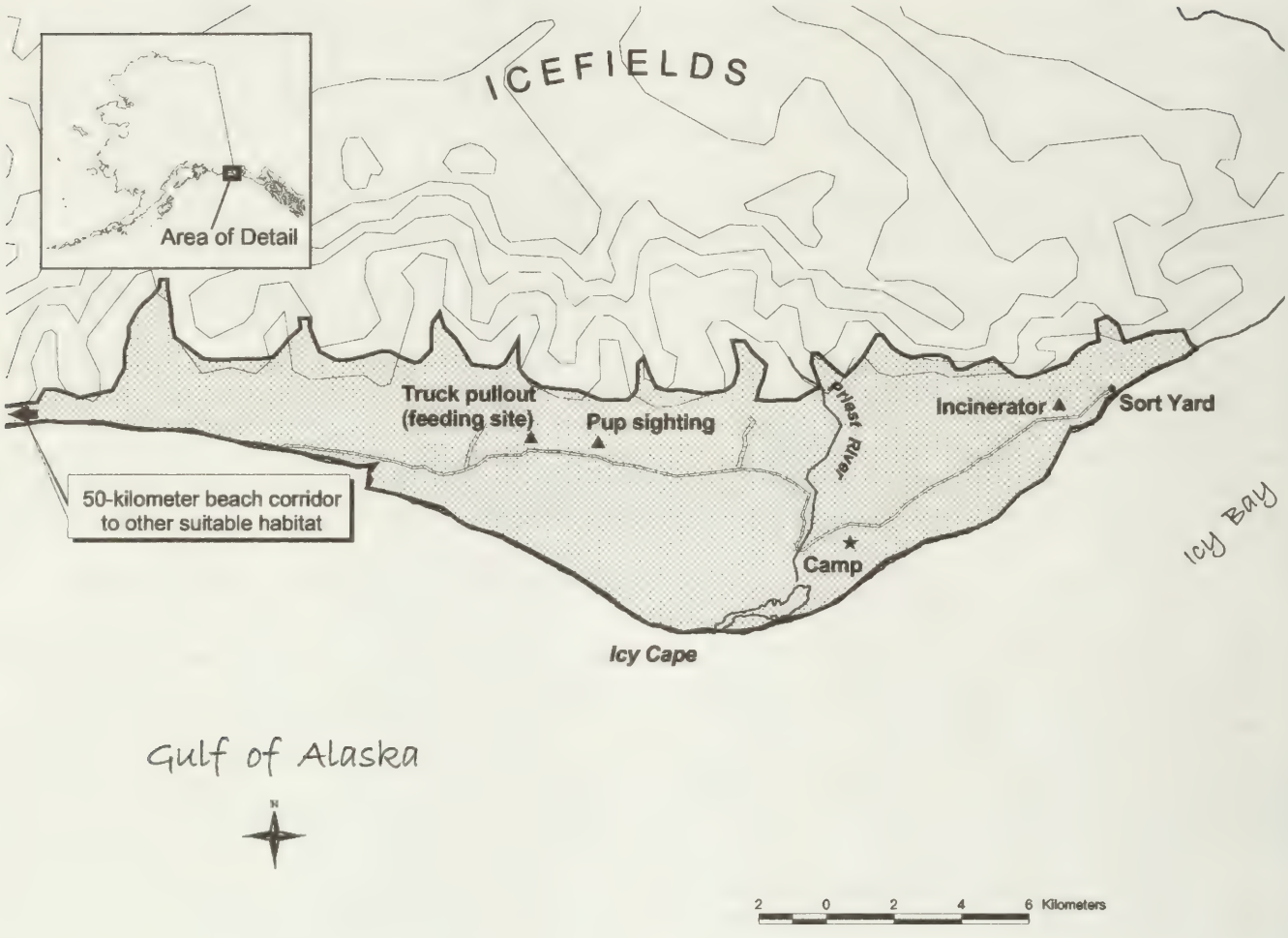

FIGURE 1. Detail showing location of the Icy Bay logging camp relative to available wolf habitat (shaded area) in the vicinity of Icy Cape.

ponded to the boys' cries for help and approached to within 1 m while shouting and throwing rocks. The dog bit at the wolf's hind legs, but the wolf focused on the boy and largely ignored the harassment by both the dog and rescuers. At one point the wolf released its grip on the boy after being struck by a rock, but then attacked again. Eventually, when the dog positioned itself between the child and the wolf, a rescuer grabbed the boy and carried him away (Alaska Department of Public Safety, 2000*; S. Norberg and T. Thompson, Icy Bay, Alaska, personal communication).

The dog and the three remaining rescuers drove the wolf into the forest, but the wolf was defiant and reluctant to leave. Less than 10 minutes later, Keith's father arrived with a rifle. He walked into the forest and briefly called with a predator call. Almost immediately, the wolf stepped onto a trail 80 m behind him. The man turned and fired once, killing the wolf (Alaska Department of Public Safety 2000*).

A post-mortem examination revealed no apparent physical disabilities that would have contributed to the wolf's behavior. The wolf's size (approximately 35 kg) appeared small compared to other wolves in that area, but body fat levels were normal. The stomach contained remnants of natural foods, including cartilage and hair, possibly from a Beaver. The wolf tested negative for rabies and canine distemper. The wolf wore a tightly fitting radio collar that had caused hair loss on its neck, but no abrasion to the skin (Blake 2000*).

The Wolf's History

The wolf had been captured and fitted with a radio collar in March 1996 at 10 months of age (Alaska Department of Public Safety 2000*). It dispersed from its natal range (100 km west of Icy Bay) during winter 1997–1998. The radio was not heard again, but a radiocollared wolf, believed to be the same wolf, was seen twice by Alaska Department of Fish and Game (ADF&G) biologists in June 1998, 50 km west of Icy Bay. During one of those sightings the collared wolf was with another, uncollared wolf.

Almost a year later, in April 1999, the collared wolf was seen on a logging road 18 km west of Icy Bay. The previous day, Mooney witnessed a truck driver throw food to an uncollared female wolf at the same site. Following that feeding incident, the logging company reemphasized their policy prohibiting the feeding of wildlife and there were no further known cases of wolves being fed.

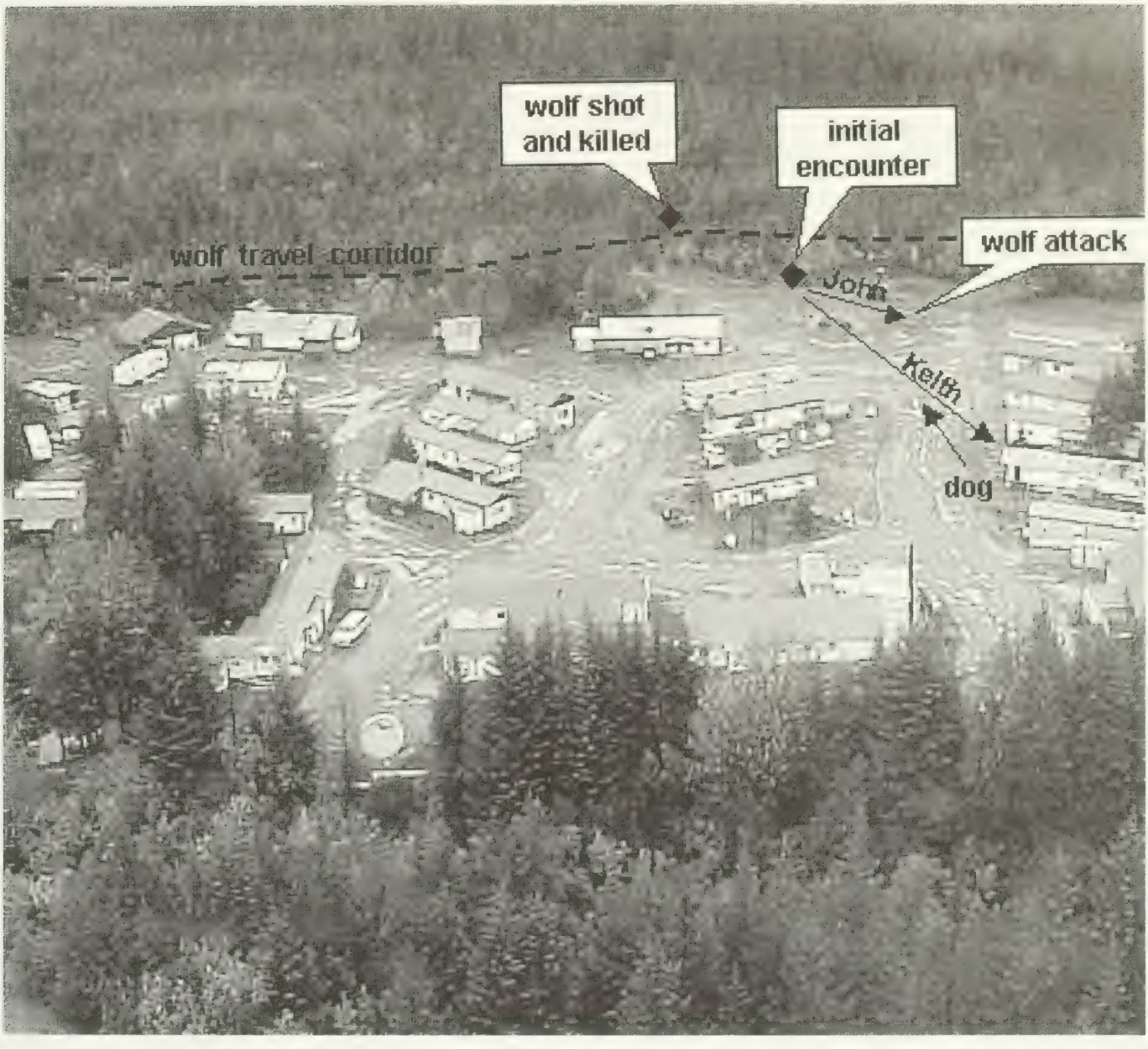

Figure 2. Aerial photo of the Icy Bay logging camp showing location of the wolf encounter and attack sites. Photo by P. Mooney.

Over the next year, the collared wolf exhibited increasingly bold behavior. It was seen at least seven times by camp residents along the north perimeter of camp, on the road, and near the log sort yard. Between September 1999 and April 2000, people encountered the wolf at close range at least four times, but it never approached or demonstrated aggressive behavior toward people. However, the wolf was suspected in an attack that seriously injured a dog in summer 1999.

The pattern of sightings suggests the wolf occupied a territory and was not a transient. At 5 years of age most wolves have passed through a dispersal period during which they disassociate from their natal pack and travel alone before finding a mate (Fuller et al. 2003). The collared wolf's dispersal began at the normal age of 2 years. The sightings of the collared wolf and a female wolf at the same location on consecutive days in April 1999 suggests a mated pair, and on 2 July 2000 a female wolf with five pups crossed the road 6 km from the camp in front of an approaching vehicle. One of the pups was photographed by the driver. That sighting confirmed a den or rendezvous site was nearby. Those pups would have been born in April or early May 2000, about the time of the attack.

The collared wolf was often seen near the sort yard so it routinely traveled the 15 km between the denning area and the sort yard. A dry streambed along the northern perimeter of the camp provided a natural travel route. Residents frequently saw the collared wolf near camp in early summer, but not in late summer of 1999. That change in activity coincided with increased food availability as salmon moved into streams 6 km from the camp.

The camp's garbage was collected and incinerated daily. The Alaska Department of Public Safety investigator inspected all garbage disposal facilities and

specifically asked 11 camp residents if they knew of wolves being fed or obtaining food near the camp. The investigator concluded there was no evidence that the animal was drawn into the area by active or passive feeding within the year prior to the attack (Alaska Department of Public Safety 2000*).

Discussion

Until the day of the attack, the collared wolf had never approached or acted aggressively toward people, but it had demonstrated increasingly fearless behavior. The habituation process was probably facilitated by the camp's central location in the small, isolated area of wolf habitat. The wolf probably encountered people frequently, but people would have been unaware of the wolf's presence during most encounters, because the camp, road, and sort yard were all surrounded by dense forest. The presence of dogs may have encouraged the wolf to periodically patrol and scent mark along the camp's perimeter. Company policy made it difficult for camp residents to hunt or trap near the camp or near worksites, thereby creating a defacto wolf protection zone where wolves were not conditioned to avoid humans. That pattern of frequent, low intensity (i.e., passive and inconsequential) encounters, irregularly spaced over a long period, is the ideal recipe for habituation (Kimmel 1973).

It seems unlikely that agonistic behavior toward the dog precipitated the wolf's attack because the dog was indoors until just before the attack and was 50–100 m from the boys during the wolf's initial approach. The dog skirmished with the wolf at least three times, but suffered no injuries. During the attack, the wolf focused on the boy and ignored the dog, but both boys had been with the dog earlier that morning. It's possible the dog's scent on their clothing played a role in the wolf's initial approach.

Snarling behavior is generally associated with agonism in wolf social interactions and can precede either offensive or defensive aggression (Zimen 1982). High-ranking wolves harass subordinates by crouching and threatening to spring, baring their teeth, or with an open mouth (Mech 1970). However, the snarling behavior witnessed by the boys prior to the Icy Bay attack does not rule out predation as a motivation. Among several predatory attacks upon children in India, wolves stalked toward children then snarled or showed their teeth before attacking (K. Rajpurohit, Wildlife Institute of India, personal communication).

Predation involves a sequence of connected behaviors that include: (a) orientation toward the prey; (b) following (i.e., stalking or rushing approach); (c) catching, and in the case of small prey; (d) carrying (Fox 1971). Several characteristics of the John Stenglein attack suggest the wolf developed a highly aroused predation response because (1) the wolf ventured from the forest to pursue the boy across an open gravel pad; (2) the wolf attempted to carry and drag the boy back to dense cover; (3) the wolf sustained the attack in the presence of rescuers; (4) the wolf reluctantly left the attack site after the boy had been rescued; and (5) the wolf remained hidden in the forest near the attack site and responded to a predator call within minutes after the incident.

When faced with conflicting stimuli, animals can exhibit behaviors that are compounds of separate acts that may be partially inhibited, ambivalent, or alternating (Colgan 1989). The sequence and timing of events in the Icy Bay attack suggest the wolf hesitated before chasing the boy, possibly undergoing a transition from an agonistic threat to a predatory response. The hesitation could also reflect the lack of a prey image for humans, but wolves have been known to change their behavior toward people from submissive to dominant or from habituated to predaceous, based on only one or a few instances where they observe vulnerability (Strickland 1999; McNay 2002a). John ran approximately 40 m before the wolf attacked. The boy ran slowly and awkwardly in oversized boots, eventually falling. That visual image of vulnerability, accompanied by the boy's cries for help, was probably significant in eliciting the wolf's subsequent response, which was no longer inhibited. The wolf's attempt to carry and drag the boy away from rescuers cannot be explained as an agonistic act and despite the possible agonism reflected in the wolf's initial approach, the final result clearly contained elements of predation.

In a study of wolves 150 km west of Icy Cape, wolf pack territories ranged from 193 to 597 km^2 and averaged 428 km^2 (J. Carnes, University of Idaho, personal communication), but only a 100 km^2 of useable habitat was available near Icy Bay. The sighting of a female wolf with pups on the road 6 km from the logging camp suggests the attacking wolf was paired with a female that produced pups, it would be unlikely another adult male simultaneously occupied such a restricted territory.

Typically male wolves carry food to the denning female (Harrington and Mech 1982; Mech et al. 1999). That provisioning places increased energetic demands on the male which could affect predation rates and motivation. For example, predation rates by Coyotes *(Canis latrans)* on domestic sheep declined when pups of depredating adults were destroyed (Till and Knowlton 1983). Carbyn (1989) suggested nutritional stress on Coyotes during the reproductive season, in combination with habituation to humans, contributed to predatory attacks by Coyotes on children. Coyotes in those attacks behaved similar to the Icy Bay wolf by repeatedly biting the victims, attempting to drag victims away from the attack site, and exhibiting reluctance to abandon their attack even when rescuers intervened.

Some biologists who commented on the attack during the course of the ADPS investigation discounted the idea of a predatory motivation because the wolf was capable of quickly killing the boy, but did not

(Alaska Department of Public Safety 2000*). However, interruption of the predation sequence can result in confusion, conflicted response, and failure to kill the prey (Zimen 1978). Furthermore, immediate killing is not a prerequisite for successful predation. In Bihar, India, 92 children were preyed upon by wolves between 1989 and 1995. Wolves grabbed children by the neck, waist, head, chest or thigh then carried them away from the attack site. Twenty children were rescued alive after bystanders chased the wolves (Rajpurohit 1999); a 4-year-old boy was rescued after villagers pursued the wolf for 2 km (Jhala and Sharma 1997). Even with natural prey, wolves commonly do not immediately kill. During Caribou (*Rangifer tarandus*) calf mortality studies in Alaska, biologists observed wolves carry live calves to cache or feeding sites before killing the calf (R. Boertje, ADF&G, personal communication). Therefore, predatory intent cannot be ruled out in the Icy Bay case simply because the boy was not killed.

What seems most clear is that the Icy Bay wolf became habituated to the presence of people. Habituation was a factor common to predatory attacks by Coyotes on children in North America (Carbyn 1989) and presumably to wolf predation on children in India where wolves continually live among high densities of people and natural foods are often scarce (Jhala and Sharma 1997; Rajpurohit 1999). In the Icy Bay case, food conditioning may have initially facilitated the habituation process, but there was no evidence the attack resulted from a recently reinforced, food-conditioned approach response.

Acknowledgments

We are indebted to the people of Icy Bay who openly discussed their experiences related to the attack. Those residents included Betsy Beeks, Samantha Norberg, Carol Simpson, Diane Stenglein, and Teresa Thompson. John Carnes provided unpublished data on wolf home range sizes. We discussed the attack with Trooper Marc Cloward who provided additional insight into findings not presented in his investigative report. We thank Shelley Szepanksi, Beth Lenart, and Laura McCarthy of ADF&G for preparation of figures and technical editing. Steve Peterson and Patrick Valkenburg of ADF&G commented on an early draft of this paper.

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Received 4 September 2001
Accepted 14 April 2005

Post-Reproductive Pacific Salmon, *Oncorhynchus* spp., as a Major Nutrient Source for Large Aggregations of Gulls, *Larus* spp.

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Christie, K. S., and T. E. Reimchen. 2005. Post-reproductive Pacific salmon, *Oncorhynchus* spp., as a major nutrient source for large aggregations of gulls, *Larus* spp. Canadian Field-Naturalist 119(2): 202-207.

On the Pacific coast of North America, the most abundant vertebrate visitors to estuaries and rivers during salmon migration are gulls, yet the utilization of salmon nutrients by these scavengers, and subsequent ecological impacts are not well documented. On two forested watersheds on the central coast of British Columbia, we tracked gull abundance during the spawning period for two consecutive years, and estimated consumption of post-reproductive salmon carcasses and eggs, as well as guano production. At Clatse River, gulls (*Larus glaucescens, L. argentatus, L. thayerii, L. californicus, L. canus, L. philadelphia)* consumed 13-26% of total salmon carcass biomass and 29-36% of all salmon eggs deposited in the system. At Neekas River, gulls consumed 11-19% of salmon carcass biomass and 7-18% of total salmon eggs. Local guano production over the 60-day period ranged from 600 kg to 1190 kg at Clatse and from 1200 kg to 2100 kg at Neekas River, and was distributed to marine, estuarine, freshwater and riparian habitats. The large aggregations of gulls and subsequent nutrient cycling observed on our study watersheds may represent a once widespread phenomenon that is now largely reduced due to recent declines in salmon populations.

Key Words: Gulls, *Larus*, nutrients, *Oncorhynchus*, salmon, spawning, consumption, eggs, carcasses, British Columbia.

In the north Pacific, large runs of spawning salmon (*Oncorhynchus* spp.) contribute substantial quantities of nutrients to aquatic and terrestrial food webs (Bilby et al. 1996; Willson et al. 1998; Willson 2004). Nutrients from salmon carcasses are used extensively by many wildlife species such as bears, marten, wolves, eagles, gulls, and ravens and become incorporated into terrestrial vegetation and invertebrate communities (Reimchen 1994*, 2000; Ben-David et al. 1998; Cederholm et al. 2000*; Helfield and Naiman 2001; Darimont and Reimchen 2002; Hocking and Reimchen 2002). The most numerous, yet least well-studied vertebrates that feed on post-reproductive salmon are gulls, which congregate in the thousands on streams throughout the north Pacific during their southward autumn migration (Mossman 1958; Campbell et al. 1990; Skagen et al. 1991). Migration and feather molt, both energetically demanding activities, require rapid accumulation of lipids (Jenni and Jenni-Eiermann 1998; Stocker and Weihs 1998; Hamer et al. 2002). These metabolic demands in addition to harsh weather conditions in the fall and winter can lead to high mortality in gulls, especially for juveniles (Burger 1993; Verbeek 1993; Hamer et al. 2002).

In this manuscript, we quantify gull abundance and foraging activity on two salmon streams of coastal British Columbia. We examine temporal shifts in abundance of gulls on each salmon stream, salmon and egg consumption by each species of gull and the recycling of salmon nutrients via guano production.

Methods

Our study was conducted on the on the central coast of British Columbia at the Clatse River (52°20.6'N; 127°50.3'W) and the Neekas River (52°28.4'N; 128° 8.0'W), both of which support spawning populations of Chum (*Oncorhynchus keta*) and Pink (*O. gorbuscha*) salmon that spawn from late August until early November. Approximately 1 km from the mouth of the Clatse River and 2.1 km from the mouth of the Neekas River, 5-10 meter waterfalls act as barriers to further upstream migration of the salmon. These localities, both of which support more than 20 000 spawning salmon, are described in detail elsewhere (Hocking and Reimchen 2002; Mathewson et al. 2003).

We made a total of 33 separate gull surveys comprising 8-9 per year at each watershed throughout the salmon spawning period. All surveys were made during low tide and included both estuary and river habitats. Gulls were counted and identified. Large gulls were grouped to facilitate identification from a distance and later identified to species in sub-sets. Among gulls that were foraging, we recorded feeding technique, and obtained classifications (surface-seizing, surface-plunging, carcass-scavenging) from Ashmole (1971). We recorded food item (carcass or eggs) consumed by sub-sets of foraging Mew Gulls. The study period extended from 9 September to 17 October in 2002 and from 25 August to 21 October in 2003.

Daily consumption of salmon carcasses and eggs was calculated for each gull species. We used the consumption model modified from Bishop and Green (2001) as follows:

$$C = FMR/MEC \times P \times M$$

where C = consumption (g day^{-1}), FMR = field metabolic rate (KJ day^{-1}), MEC = metabolizable energy

coefficient of salmon or eggs; P = proportion of salmon or eggs in diet; M = mass of salmon or eggs (g) needed to produce 1 KJ energy. FMR was calculated using the allometric equation for free-living seabirds from Birt-Friesen et al (1989):

$$FMR = 10^{(3.08+0.667\log M)}$$

where average body mass (M, in kg) was obtained from Dunning (1993) (Table 1). MEC was assumed to be 0.75 for both salmon flesh and eggs (Castro et al. 1989; Bishop and Green 2001). Energy density of senescent salmon flesh is 2.95 KJ g^{-1} (wet mass) (Hendry and Berg 1999), and for salmon eggs it is 7.60 KJ g^{-1} (wet mass) (Jonsson et al. 1998). Calculated values of FMR and consumption are shown in Table 1. Total consumption by gulls per day was derived from the mean gull count per day for each watershed. Based on the surveys at each watershed, we estimated mean daily gull abundance using two methods (1) the mean abundance of gulls derived from the original 8-9 surveys and (2) the interpolated mean, where each day was assigned a value based on temporal shifts in abundance. Although gulls occupy salmon streams throughout most of the 3-month spawning period, we estimated consumption for a 60-day period, the interval over which we had detailed data.

We calculated the proportion of total salmon biomass consumed by gulls using total consumption estimates relative to number of salmon returning to the river to spawn (escapement). Salmon escapement was obtained for our study streams in 2002 and 2003 from the Department of Fisheries and Oceans (Terry Palfrey, personal communication, Table 2). Average intact carcass mass for Pink and Chum salmon at our study sites was obtained from M. D. Hocking (personal communication, Table 2). Fecundity and egg wet mass for Pink and Chum salmon (northern mainland coast) were obtained from Beacham and Murray (1993). Pink Salmon fecundity was 1633 eggs/female and egg wet mass was 0.175g; Chum fecundity was 3173 eggs per female and egg wet mass was 0.278g. A 1:1 sex ratio was used for both Chum and Pink salmon (Heard 1991; Salo 1991). Total biomass of salmon and eggs in the system are summarized for the two watersheds in both years in Table 2.

We calculated guano production for each species per day based on Burger et al. (1978) for Kelp Gulls: G = 36.1g d^{-1} kg^{-1}, where G = output (dried) per kg body mass per 24 hrs. We adjusted this value to the average mass of each gull species. This estimate is congruent with that of Portnoy (1989) who found that Herring Gulls (mass = 1.1kg) produced 39.4 g day^{-1}.

Results

In both watersheds, six gull species were observed to feed on salmon carcasses and eggs: Glaucous-winged (*Larus glaucescens*), Herring (*L. argentatus*), Thayer's (*L. thayeri*), California (*L. californicus*), Mew (*L. canus*), and Bonaparte's (*L. philadelphia*) gulls. The large-bodied gulls (Glaucous-winged, Herring, Thayer's, and California gulls) mainly scavenged for salmon carcasses and occasionally consumed drifting eggs. Bonaparte's Gulls consumed eggs exclusively and most often hovered, "surface-plunging" for eggs. Bonaparte's Gulls also floated and "surface-seized" eggs from below the surface. Mew Gulls rarely surface-plunged; most of the time they were observed to either surface-seize or dislodge eggs from gravels with their feet. From behavioural observations of sub-sets of Mew Gulls,

TABLE 1. Average body mass (Dunning 1993), calculated field metabolic rate, and daily consumption of eggs or carcasses for large gulls (Glaucous-winged, Herring, Thayer's, California gulls) Mew Gulls, and Bonaparte's Gulls.

Species	Mean body mass (g)	Field metabolic rate (KJ/day)	Consumption of eggs (g/bird/day)	Consumption of carcasses (g/bird/day)
Large gulls	1073.0	1258.9	220.9	569.0
Mew Gull	403.5	656.2	115.1	296.6
Bonaparte's Gull	212.0	426.6	74.9	192.8

TABLE 2. Wet mass of salmon carcasses (M. D. Hocking, personal communication) and wet mass of eggs (Beacham and Murray 1993) deposited by Pink and Chum salmon at the Clatse and Neekas Rivers. Salmon escapement (Department of Fisheries and Oceans) was used to calculate total mass of carcasses and eggs deposited in each watershed in 2002 and 2003.

Watershed	Species	Mean carcass wet mass (Kg)	Mass of eggs (g/female)	2002 escapement	Total mass of salmon (Kg)	Total mass of eggs (Kg)	2003 escapement	Total mass of salmon (Kg)	Total mass of eggs (Kg)
Clatse	Pink	1.1+/-0.1	285.8	25000	27500	3573	25000	27500	3573
	Chum	4.2+/-0.2	882.1	4300	18060	1897	6000	25200	2646
	Total			29300	45560	5470	31000	52700	6219
Neekas	Pink	1.3+/-0.1	285.8	60000	78000	8574	15000	19500	2144
	Chum	3.4+/-0.2	882.1	19000	64600	8380	35000	119000	15437
	Total			79000	142600	16954	50000	138500	17580

TABLE 3. Total consumption of salmon carcasses and eggs during the 60-day study period and proportion of the total salmon and egg biomass in the system consumed by gulls.

Watershed	Year	Total carcass consumption (Kg) original*	interpolated**	Proportion of total salmon biomass	Total egg consumption (Kg) original*	interpolated**	Proportion of total egg biomass
Clatse	2002	6318	7931	0.13 - 0.17	1594	1987	0.29 - 0.36
	2003	14221	10419	0.19 - 0.26	2150	1868	0.30 - 0.34
Neekas	2002	15785	19349	0.11 - 0.14	1311	1515	0.07 - 0.09
	2003	26386	24650	0.18 - 0.19	3012	3168	0.17 - 0.18

*derived from mean of original counts
**derived from mean of interpolated counts

approximately 93% consumed eggs and 7% consumed carcasses (n = 11, s = 0.19). Gulls obtained eggs buried in the stream gravels, as well as those already floating downstream. They were also observed taking eggs from carcasses. Feeding intensity of large gulls was highest at low tide, when most carcasses in the estuary were exposed.

Gull abundance fluctuated over time at the two watersheds (Figure 1). At Clatse River, total daily counts of gulls reached a maximum of 1979 (13 October 2003), of which approximately 45% were large gulls. At Neekas River, maximum counts were 3594 (21 October 2003) of which 64% were large gulls. At both watersheds, Glaucous-winged and Herring gulls were the dominant species among the large gulls. Large gulls increased in abundance over the spawning period in both years at both watersheds whereas Mew and Bonaparte's gull abundance was less predictable (Figure 1). At the Clatse River, Mew and Bonaparte's gulls peaked in numbers and began to decline in early October 2002 and mid-October 2003 (Figure 1a, b) whereas at the Neekas River they did not follow a discernable pattern (Figure 1c,d). Total numbers of Mew and Bonaparte's gulls were similar between watersheds, whereas greater numbers of large gulls occurred at Neekas River.

Total consumption estimates of salmon carcasses and eggs varied between years and watersheds (Table 3). We estimate that 11% to 26% of total salmon carcass biomass and 7% to 36% of salmon egg biomass was consumed by gulls during the study period (Table 3). Carcass consumption was higher at the Neekas than the Clatse River, but proportions of total salmon biomass consumed were slightly less at the Neekas than the Clatse River. Although egg consumption was similar at the two watersheds, substantially higher proportions of total egg biomass were consumed at Clatse compared to Neekas River (Table 3). In general, consumption was higher in 2003 than 2002 for both watersheds.

Based on gull counts and body mass, we estimated total guano production. At Clatse River, guano output ranged from 596 kg to 748 kg in 2002 and 907 kg to 1192 kg in 2003. At Neekas River, this ranged from 1201 kg to 1463 kg in 2002 and 2006 kg to 2104 kg in 2003. Based on observed foraging and resting locations of gulls, guano was distributed into multiple habitats including the river, riparian zone, estuary, and ocean.

Discussion

Gulls were significant consumers of the salmon resource and used a variety of foraging techniques and tissue types. There is an energy trade-off between the calorie-rich eggs, which require active searching, and the highly available yet low energy-density carcasses. Bonaparte's Gulls, the smallest of the gulls, are well adapted to aerial foraging and surface-seizing and commonly feed on insects and zooplankton (Baltz and Morejohn 1977; Vermeer et al. 1987; Taylor 1993). Their ability to hover above water for extended periods of time may facilitate their ability to effectively spot and capture eggs in the river. The larger gulls, in contrast, with a greater body mass and wing-loading, may incur additional energy costs of continuous-flapping flight which may outweigh the benefits of obtaining the more energy-rich food. These gulls were observed on occasion to surface-plunge for eggs, indicating that at certain times, benefits of capturing eggs outweighed energy costs. Although other food sources such as benthic invertebrates were available in the estuaries, we only observed gulls foraging on salmon tissues and eggs. Gulls tend to maximize their utilization of temporary resources, focusing on localized concentrations of prey (Shealer 2002), and it is probable that when eggs and carcasses are easily available on salmon streams, gulls feed solely on this resource.

Abundance of gulls at the Clatse and Neekas Rivers fluctuated over the study period and appeared to correspond with food availability. Large gull abundance increased over time on each watershed in both years, corresponding with the accumulation of spawned-out salmon on the stream banks and in the estuary. Abundance of Bonaparte's Gulls and Mew Gulls, however, was not correlated with carcass accumulation. We suspect that the rate of egg loss, which is associated with spawning density and flooding events, may be an important predictor of Mew and Bonaparte's Gull abundance. The two watersheds had similar numbers of Mew and Bonaparte's Gulls despite the higher biomass of salmon at the Neekas River, indicating that comparable quantities of eggs were being lost from

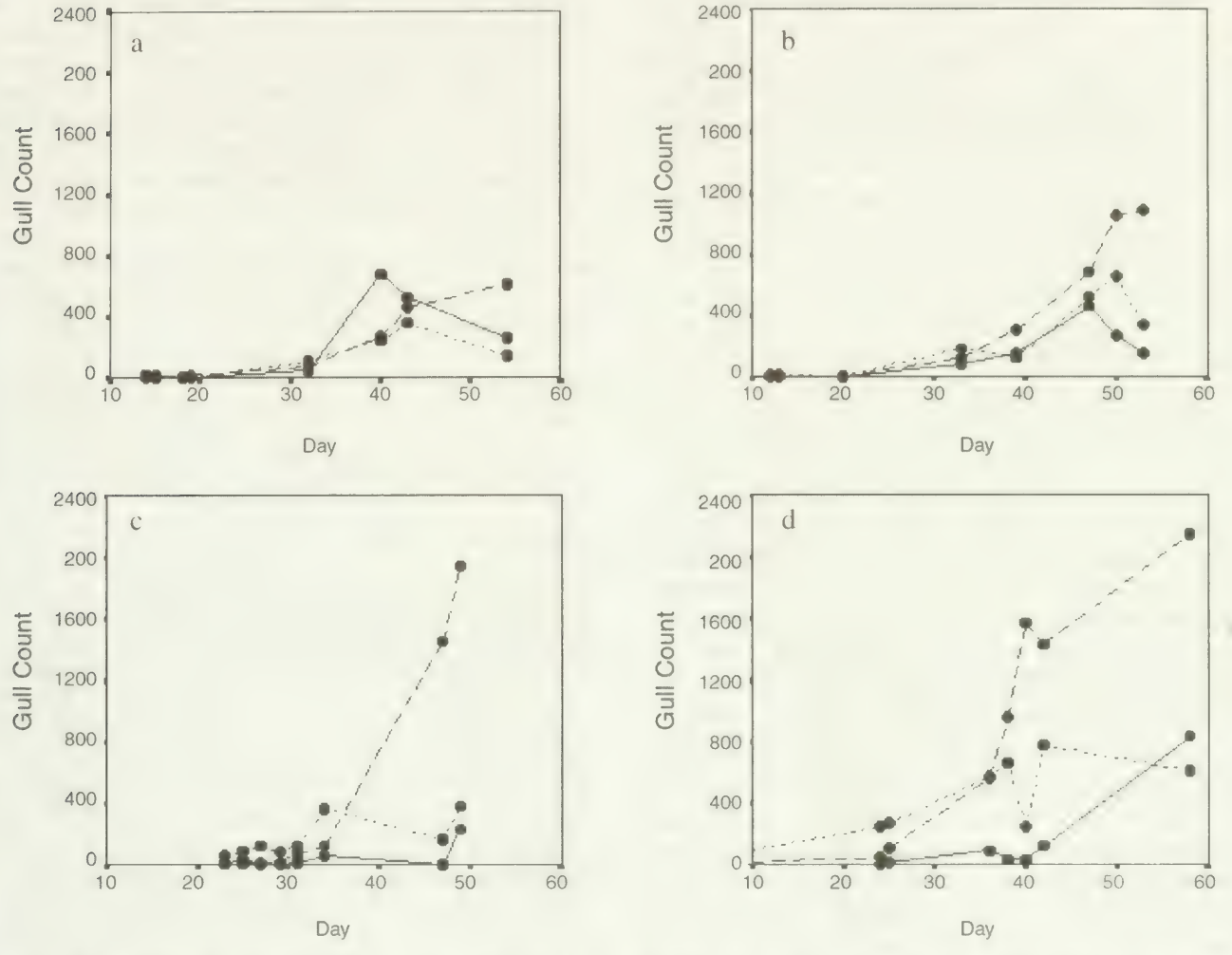

FIGURE 1a-d. Change in abundance of gulls over time (day 1 = 25 August; day 60 = 23 October) for Clatse River: (a) 2002 and (b) 2003 and Neekas River (c) 2002 and (d) 2003. Dashed lines represent large gulls (Glaucous-winged Gulls, Herring Gulls, Thayer's Gulls, California Gulls), dotted lines represent Mew Gulls, and solid lines represent Bonaparte's Gulls.

the two watersheds even though the Clatse River had fewer spawning salmon. High stream velocity can result in egg loss, causing eggs to be washed out of redds after being deposited (Vronskii and Leman 1991). This effect may be accentuated at Clatse River where recent logging in the headwaters will have lead to higher stream velocities and reduced gravel stability. Egg loss from salmon redds can also be linked with high salmon spawning density, which results in redd superimposition and subsequent egg dislodgement (Fukushima et al. 1997). It is possible that fluctuations in gull abundance were related to timing of migration rather than prey abundance. Mace (1983) observed aggregations of Bonaparte's Gulls feeding on juvenile salmonids in the spring and found abundance of gulls to be directly related to migration.

Gulls were major consumers of both salmon carcasses and eggs. Our estimates for consumption of carcasses at the Neekas and Clatse rivers are conservative because our 60-day study period ended before gulls had departed from the stream. Extrapolating abundance throughout the duration of the spawning period might increase consumption by as much as 30%. Our results are comparable to those of other studies of gulls feeding on fish or eggs (Gabrielsen et al. 1987; Haegele 1993; Bishop and Green 2001). High numbers of egg-eating gulls at the Clatse River led to a substantial proportion (29-36%) of eggs deposited in the system being consumed. Only a small proportion of eggs would have been dislodged from buried redds; most eggs were already floating downstream before capture by gulls. It is not unusual for large quantities of eggs to be lost from salmon redds; for example, average egg loss rates of 48.6% and 56% have been reported for Pink Salmon (Eniutina 1972; Heard 1991). In general, higher proportions of salmon and eggs were consumed in 2003 than 2002, largely because there was less total salmon available in 2003. Between-year differences at the Neekas River must be interpreted cautiously, however, because of the short study period in 2002.

Gulls contributed to the cycling of nutrients from salmon into terrestrial and aquatic ecosystems through guano and feather deposition. Seabird guano has been reported to enrich plants in nitrogen and phosphorus (Anderson and Polis 1999; Garcia et al. 2002), increase abundance of terrestrial arthropods (Sanchez-Pinero and Polis 2000), and increase primary productivity in the intertidal zone (Bosman and Hockey 1986). Guano from gulls and other avian scavengers on salmon streams likely contributes to the nitrogen and

phosphorous content of otherwise nutrient-deprived coastal forests and streams (Waring and Franklin 1979; Kiffney and Richardson 2001). In addition, gulls undergo an annual molt after breeding (Taylor 1993; Vandenbulcke 1989), and their feathers, containing high concentrations of mineral elements and energy (Williams and Berruti 1978) are shed into the riparian zone, stream, and estuary.

Salmon streams may provide an important food resource for gulls, particularly the smaller species such as Mew and Bonaparte's gulls. Salmon streams offer a highly predictable, nutritional and accessible food source to gulls dispersing from breeding grounds in search of abundant food resources at a time of high energy expenditure (feather molt, migration) and high juvenile mortality (Burger 1993; Hamer et al. 2002). There are roughly 2500 spawning streams in British Columbia, many of which attract aggregations of gulls during the autumn and winter. Assemblages of gulls have been reported to utilize salmon streams in Washington (Skagen et al. 1991), Vancouver Island (personal observation), the Queen Charlotte Islands (Reimchen 1992*) and Alaska (Mossman 1958). The large numbers of gulls observed on the Clatse and Neekas Rivers, which have relatively intact salmon runs, are representative of an ecological phenomenon that has been greatly diluted throughout the Pacific Northwest. Gresh and Lichatowich (2000) estimated a 93-95% reduction in salmon biomass on the west coast of North America over the last century which results reduced availability of this food source for gulls and for numerous other vertebrates species that utilize salmon nutrients (Cederholm et al. 2000*). The importance of gull assemblages to the ecology of coastal terrestrial ecosystems is unknown, but gulls have the potential to be important nutrient vectors and thus may contribute to the primary productivity of nutrient-deprived terrestrial systems.

Acknowledgments

We thank Alan Burger for his helpful comments on the manuscript, Karen Petkau, Morgan Hocking, Janine Arnold, Bob Wilkerson, Sara Steinke and Jocelyn Akins for assistance in the field, Chris Darimont, Raincoast Conservation Society and Larry Jorgenson for providing accomodation in the field, Terry Palfrey at the Department of Fisheries and Oceans for fish escapement data, The Natural Sciences and Engineering Research Council of Canada (NSERC), The Friends of Ecological Reserves, The David Suzuki Foundation, Mountain Equipment Co-op Environment Fund, Bird Studies Canada, and Science Horizons Youth Internship Program for financial support, and The Heiltsuk Nation for allowing this study to take place in their territory.

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Received 12 March 2004
Accepted 8 March 2005

Microhabitat Characteristics of Lapland Longspur, *Calcarius lapponicus*, Nests at Cape Churchill, Manitoba

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Boal, Clint W., and David E. Andersen. 2005. Microhabitat characteristics of Lapland Longspur, *Calcarius lapponicus*, nests at Cape Churchill, Manitoba. Canadian Field-Naturalist 119(2): 208-213.

We examined microsite characteristics at 21 Lapland Longspur (*Calcarius lapponicus*) nests and land cover types in which they occurred in Wapusk National Park, Cape Churchill, Manitoba. Nests were located in four of six physiographic-vegetation land-cover types. Regardless of land-cover type, all but one nest was built on a pressure ridge or mound. Nests were built midway between the bottom and top of ridges or mounds with steeper slopes than was randomly available. Longspur nests had a distinctive southwest orientation ($P < 0.001$). Longspurs selected nest sites that consisted of comparatively greater amounts of shrub species and lesser amounts of moss than were randomly available. Nests were generally well concealed by vegetation (mean = 67.0%) and concealment was negatively associated with amount of graminoid species at the nest ($P = 0.0005$). Our nesting habitat data may facilitate a better understanding of breeding Lapland Longspur habitat requirements, and potential impacts of habitat degradation by increasing Snow Goose (*Chen caerulescens*) populations in the study area.

Key Words: *Calcarius lapponicus*, Lapland Longspur, *Chen caerulescens*, Lesser Snow Goose, microhabitat, Cape Churchill, nesting habitat, Manitoba.

The Lapland Longspur (*Calcarius lapponicus*) is one of the most common breeding passerines of the Arctic (Rising 1996; Gilg et al. 2000; Henry and Mico 2002; Hussell and Montgomerie 2002), with a wide distribution across well-vegetated tundra landscapes of North America and Eurasia (Hussell and Montgomerie 2002). However, because breeding by Lapland Longspurs occurs outside of the Breeding Bird Survey (Dunn 1997), little information is available concerning population trends (Hussell and Montgomerie 2002). The species has experienced substantial population declines in the region of Churchill, Manitoba, since the 1930s (Taverner and Sutton 1934; Jehl and Smith 1970; J. R. Jehl, *in* Hussell and Montgomerie 2002). It is now reported to be absent from the area except in small, scattered groups along the coast to Cape Churchill (Hussell and Montgomerie 2002).

Understanding a species' habitat requirements is a key element of understanding population trends. Unfortunately, most nesting habitat data for Lapland Longspurs are qualitative. Breeding Lapland Longspurs are reported as most common in wet tundra, thickly vegetated uplands, sedge margins along streams and ponds, and hummocks and sedges in marshes (Rodrigues 1994; Rising 1996; Henry and Mico 2002). Nests are typically placed in a depression in the ground on the side of a bank or hummock (Hussell and Montgomerie 2002), and consist of a cup of coarse sedges, grasses, moss, and roots lined with finer materials such as feathers, hair, and finer grasses (Watson 1957; Rising 1996; Baicich and Harrison 1997). However, few quantitative data are available on nest dimensions (Brandt 1943; Grinnell 1944; Madsen 1981), orientation (Rodrigues 1994), vegetation characteristics (Rodrigues 1994), or nest concealment of Lapland Longspur nests, all of which may relate to nest thermal conditions and concealment and, thereby, nesting success. Such information is necessary to develop a more complete understanding of the species' breeding habitat requirements. Nesting habitat information may also facilitate a better understanding of possible factors leading to local population trends. Existing data for Lapland Longspurs are primarily from the northern portions of the species' breeding range (see Hussell and Montgomerie 2002 for review). Fewer published data are available from the more southerly extent of the species' range, and those available are dated (Taverner and Sutton 1934; Grinnell 1944; Jehl and Smith 1970). Here we present data on microhabitat characteristics of Lapland Longspur nests at Cape Churchill, Manitoba, in June 2003. This coincided with the peak of nesting activity by the species in the area.

Study Area

The study area center is approximately 2 km west of Hudson Bay in Wapusk National Park, and situated 35 km east of Churchill, Manitoba and 15 km southeast from La Pérouse Bay (58°39'N, 93°11'W). The study area is characterized as a tundra biome, consisting of a series of coastal salt marshes, willow (*Salix* spp.) and spruce (*Picea* spp.) patches, beach ridges, and an inland matrix of large, permanent freshwater lakes,

ephemeral freshwater pools, and freshwater sedge meadows (Didiuk and Rusch 1979). We characterized the landscape into physiographic-vegetation communities as described by Henry and Mico (2002). Wet Sedge Meadows (WSM) were typically level, hydric lowlands with nearly continuous sedge cover and often shallow surface water. Graminoid Tundra (GRT) was mesic to hydric areas with near-continuous graminoid cover and occasional dwarf shrubs (primarily *Salix* spp.). Graminoid/Dwarf Shrub Tundra (GST) consisted of 75-100% cover of graminoids and moss, with herbs and dwarf shrubs on the occasional drier earthen hummocks. Common features of the inland matrix are low pressure ridges and mounds (i.e., earthen hummocks) created when surface ice expands during the winter and pushes peat upward (Johnson 1987). These mounds and ridges support herbs, moss, dwarf shrubs, and in lower areas, some graminoids. Some areas consisted exclusively of these mounds and ridges, and were classified as Hummocky Tundra (HT). Dwarf Shrub Tundra (DST) occurred primarily on moist but well-drained slopes, and consisted of about 50-75% cover dominated by dwarf shrubs. Dwarf Shrub/Lichen Barrens (DLB) were windblown sites at higher elevations (e.g., beach ridges), and typically had low (25-50%) vegetation cover. All of these descriptions are from Henry and Mico (2002), modified to apply to our study area.

Methods

Intensive nest searches were conducted in one 6-ha plot (North Plot) and one 3.7-ha plot (South Plot). The North Plot was primarily a HT, but the west border also consisted of GRT and WSM. The South Plot was primarily GRT with patches of HT and WSM. Intensive nest searches consisted of walking transects across the plot, watching and following longspurs observed carrying nest material, prey, or engaged in other behaviors indicative of a nearby nest, or flushing females from nests. Transects were closely spaced (e.g., approximately 20 m apart) but inter-transect distances and linearity were variable due to pools and ponds in the search areas.

The majority of Lapland Longspur nests was not located systematically. Rather, many nests were found when researchers engaged in other studies inadvertently flushed longspurs from nests, or followed longspurs observed carrying nesting material or prey.

A handheld GPS unit was used to record the UTM coordinates of each nest site and a flag was placed 10 m north of each nest to facilitate relocation. The vegetation community at the nest site and the structure (i.e., hummock, pressure ridge) in which the nest was built was recorded. The height of the nest above the base of the structure and height of the structure, slope of the structure, and orientation of the nest were recorded. Nest width and depth were recorded if such measurements would not physically disturb the nest or contents. To compare nest orientation to wind patterns, we calculated the percent of time the wind was out of the north, northeast, east, southeast, south, southwest, west, and northwest from daily records at the Nester One field station during the period of 3–24 June 2003.

To assess microhabitat vegetation at nest sites, a 20-cm by 20-cm frame was centered on the nest and a digital photograph was taken from 1.5 m above the nest. Each digital image was imported into Adobe Photoshop 7.0 and overlaid with a 1-cm × 1-cm grid (100 intersecting points). The vegetation species at each intersection was identified using collected samples and published references (Johnson 1987). Proportions of each vegetation species and litter were calculated. Identical measurements were made at paired random sites situated 10 m away and in a random direction from each nest.

We used Adobe Photoshop 7.0 to select the specific circular or elliptical area of each nest from the digital image. We then resized the image so that the narrowest span across the nest was 10 cm. Width of each image varied slightly because not all nests were perfectly circular. The image was then overlaid with a 0.5-cm by 0.5-cm grid, resulting in approximately 280–300 intersecting points. The substrate under each intersecting point was identified as vegetative cover or nest/nest contents. Percent nest cover (i.e., concealment) was then calculated as the proportion of all points identified as cover vegetation.

Descriptive statistics for nest dimensions, height, slope, orientation, and concealment are provided. We used methods described by Zar (1999) to calculate the mean bearing and 95% Confidence Interval for nest orientation. We used Rayleigh's test for uniformity to test the hypothesis that nest orientation was not random (Zar 1999). Correlation analysis was conducted to examine relationships between principal vegetation cover types and nest concealment. Rather than significance testing, we compared proportions of vegetation species at nest and random sites with 95% Confidence Intervals (Johnson 1999). Descriptive statistics reported include means and standard deviations. All statistical analyses were conducted using program STATISTICA 6.0.

Results

We located 21 active Lapland Longspur nests in the study area. Eight of the nests were located in the intensively surveyed plots, and nesting density in the two survey plots was similar (0.83 nests/ha and 0.81 nests/ha). Nearest nesting distance of any two nests was 39.5 m. Nests were located in 4 of the 6 physiographic-vegetation types. Eight nests were in GST (38%), six each were located in GRT (28.6%) and HT (28.6%), and one was located in DLB (4.8%). Despite the physiographic-vegetation types where nests were found, all but one nest were built on the side or top of a pressure ridge (38.1%) or mound (57.1%); the exception was one nest located in a grass hummock on a beach ridge (i.e., DLB).

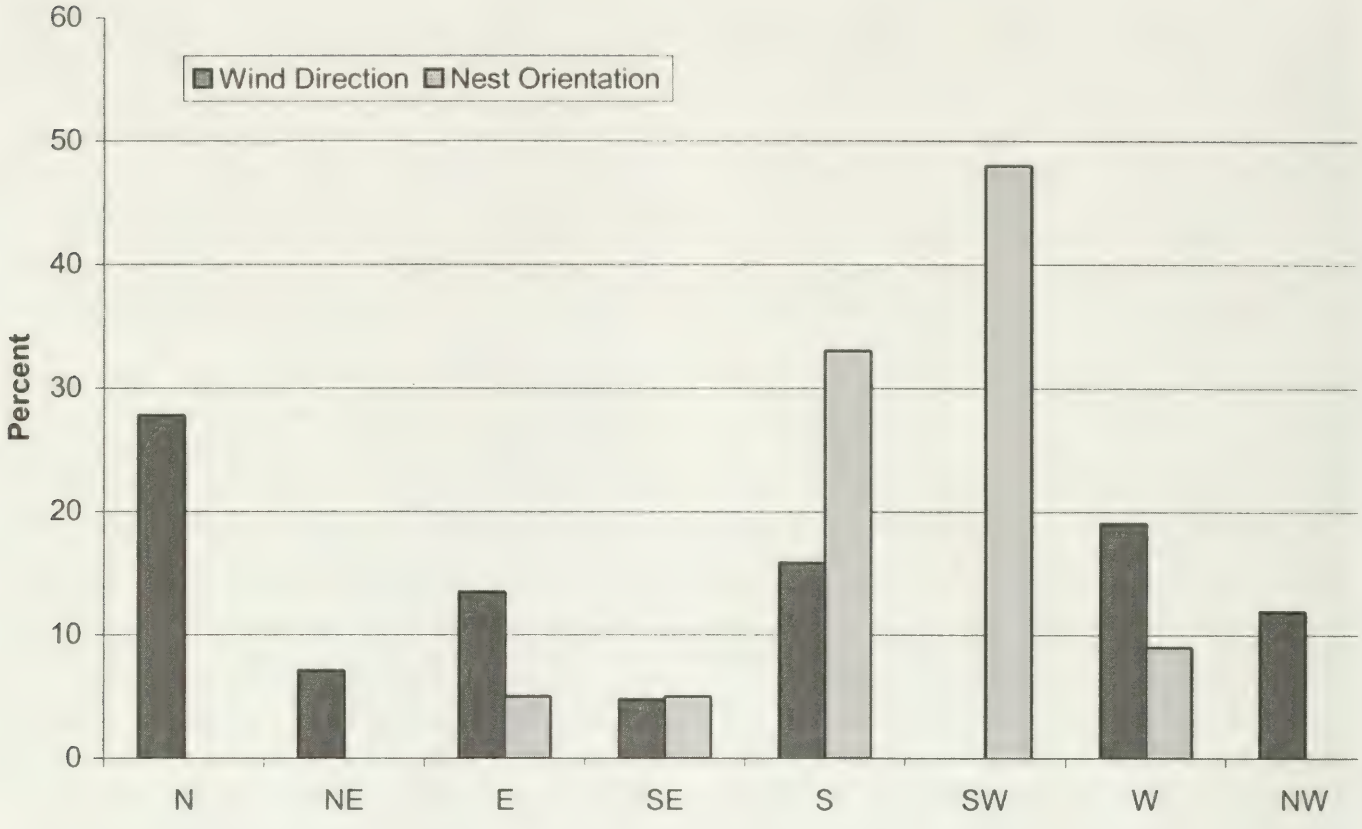

FIGURE 1. Percent of time the prevailing wind blew from the indicated directions and percent of Lapland Longspur nests with an orientation in the indicated direction at Wapusk National Park, Cape Churchill, Manitoba, 2003.

The inner dimensions of Lapland Longspur nests were 64.4 mm ± 3.9 mm (n = 11) wide and 34.7 mm ± 4.6 mm (n = 6) deep. Nests averaged 5.7 cm ± 2.2 cm above the base of their structures, which was approximately midway (mean = 55.1% ± 17.4%) up the nest structure (e.g., pressure ridge). The slope at nests (30.1% ± 17.8%) appeared to be greater than random (17.0% ± 13.8%) (difference of means = 13.1% ± 25.6%; 95% CI = 1.4 % to 24.7 %). Orientation of longspur nests was not random (z = 13.252, $P < 0.001$; Rayleigh's test for uniformity); longspur nests had a distinctive southwest orientation (mean = 208° ± 39°; 95% CI of 193° to 223°). Forty-eight percent of nests had a southwest orientation, and 33% had a southerly orientation (Figure 1). Winds were primarily from the north (28%), then west (19%), south (16%) and east (13%) (Figure 1).

Vegetation at the microhabitat scale of the nest (400 cm^2) consisted primarily of willow (primarily *Salix arctophila*; 21.8%), graminoids (primarily *Carex aquatilis*; 18.9%), moss (10.3%), litter (12.8%), Lapland Rosebay (*Rhododendron lapponicum*; 10.6%), Dwarf Birch (*Betula glandulosa*; 7.6%), and Bog Rosemary (*Andromeda polifolia* L.; 7.3%). Species occurring at lower frequency included Bearberry (*Arctostaphylos* spp.; 2.1%) Black Crowberry (*Empetrum nigrum*; 2.0%), Dry-ground Cranberry (*Vaccinium vitis-idaea*; 1.4%), Dwarf Labrador Tea (*Ledum decumbens*; 2.4%), White Mountain-avens (*Dryas integrifolia*; 0.3%), and Cloudberry (*Rubus chamaemorus*; 0.2%). Based on 95% C.I.s, it appears Lapland Longspurs selected nest sites that had a comparatively greater amount of willow, Dwarf Birch, and Lapland Rosebay, and lesser amounts of moss (Table 1).

Lapland Longspur nests were generally well concealed by vegetation (mean = 67.0% ± 22.4%; 95% CI = 56.7 – 77.2). Nest concealment appeared to be negatively associated with amount of sedge at the nest. When an obvious outlier was removed, correlation analysis indicated a convincing negative relationship between amount of sedge at nest sites and nest concealment (r = -0.705, P = 0.0005). This relationship was still apparent if the outlier was included (r = -0.474, P = 0.0298).

Discussion

Lapland Longspurs appeared to be most abundant on wet lowlands and hummocky tundra cover types (Williamson and Emison 1971; Hussell and Holroyd 1974; Montgomerie et al. 1983; Henry and Mico 2002; Hussell and Montgomerie 2002). Density estimates of the species vary both temporally and spatially. For example, average density at Barrow, Alaska, was 75 pairs/km^2 over a 19-year period, but was as high as 200 pairs/km^2 (Custer and Pitelka 1977). Spatially, density estimates from North America range from 17 to 200 pairs/km^2 (Hussell and Montgomerie 2002). Although interpretations of the density estimates in this

TABLE 1. Mean percent cover (± SD) of primary vegetative cover types at Lapland Longspur nests (n = 21) and paired sites, and mean (± SD) difference and 95% Confidence Interval for mean difference, Wapusk National Park, Cape Churchill, Manitoba, 2003.

Species	Nest		Pair		Difference		95% C.I. for mean difference
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	
Willow/Birch	29.4	20.7	19.5	19.3	9.9	20.8	0.4 to 19.4
Sedge	18.9	18.5	18.8	12.1	0.0	19.6	-8.9 to 9.0
Moss	10.3	13.8	34.7	23.4	-24.4	19.8	-33.4 to -15.3
Litter	15.0	8.5	15.1	11.0	-0.1	10.0	-4.6 to 4.5
Lapland Rosebay	10.6	19.1	1.3	3.2	9.3	16.3	1.9 to 16.7
Bog Rosemary	7.3	8.2	5.9	7.4	1.3	11.4	-3.8 to 6.5
Miscellaneous	8.5	12.6	4.6	7.8	3.9	15.3	-3.1 to 10.9

study must be made cautiously due to little spatial and no temporal replication, Lapland Longspur density at the study site (e.g., 82 pairs/km^2) does not appear to be outside reasonable expectations. In comparison, however, the current estimated density of longspurs at Churchill was 2.7 to 4.2 pairs/km^2 (J. Jehl, personal communication).

Henry and Mico (2002) found Lapland Longspurs on Banks Island, Northwest Territories, were most common in HT and GST and GRT. Although they did not examine nest sites, the pattern of distribution of birds seemed to be similar to the landscape types in which we found longspur nests. More notable is that regardless of cover type, all longspur nests but one were built into pressure mounds or ridges, even in the lower-lying graminoid-dominated cover types.

Qualitatively, Lapland Longspur nests were cups woven of dead graminoids and thickly lined with feathers and, to a lesser extent, mammal hair which is consistent with reports from other studies (Hussell and Montgomerie 2002). Inner dimensions of Lapland Longspur nests at Cape Churchill were similar to four nests measured at Churchill (mean = 67.5 mm; Grinnell 1944) and 22 nests in Greenland (mean = 63.5 mm; Madsen 1981). Inner dimension of 21 nests at Hooper Bay, Alaska, ranged from 76 to 89 mm (Brandt 1943), which is inexplicably one to two cm greater than that reported elsewhere. Cup depth of longspur nests in our study (34.7 mm) was noticeably shallower than the 42.0 mm reported by Madsen (1981), the 45 mm reported by Grinnell (1944), or the 64 to 89 mm reported by Brandt (1943). The reason for the differences in depth may have to do with sample sizes, variability of samples, or with latitude of study. This study and that of Grinnell (1944) were near the southern extent of the species' breeding range and consisted of the smallest sample sizes. The potential for harsher summer weather conditions at more northerly latitudes (Brandt 1943; Madsen 1981) may have led to longspurs building nests with deeper, and thus more thermally protected, cups.

Qualitative descriptions suggest Lapland Longspur nests are typically oriented southeast to southwest (Williamson 1968, Hussell *in* Hussell and Montgomerie 2002). Williamson (1968) suggested Lapland Longspurs may orient their nests so that the entrances are opposite from the prevailing winds and receive greater insulation. Also, Lapland Rosebay is more profuse on south slopes (J. Jehl, personal communication) and longspurs in this study appeared to select that shrub as nesting cover. Another explanation is that south-facing sides of hummocks may be free of snow earlier than other orientations (Hussell and Montgomerie 2002). On the Arctic Coastal Plain of Alaska, Rodrigues (1994) found that Lapland Longspur nests placed on the side of a ridge, polygon rim, or tussock (61% of nests) had a significant south – southwest orientation. However, 39% of the nests he located were placed in the open with no detectable orientation. The distinctive southwest orientation of nests in our study supports the earlier descriptions (Williamson 1968; Hussell and Montgomerie 2002) and research results (Rodrigues 1994) indicating Lapland Longspurs do not randomly orient their nests but select for a southerly exposure.

Lapland Longspur nests are subject to depredation by numerous species (Hussell 1974; Hussell and Holroyd 1974; Custer and Pitelka 1977; Fox et al. 1987). Nest concealment, especially from visual predators [e.g., Parasitic Jaeger (*Stercorarius parasiticus*), Snowy Owl (*Bubo scandiacus*)], may be an important aspect of nesting success. Nests in our study area were typically well-concealed by overhanging vegetation and, in many cases, were quite difficult to locate visually. Concealment of nests seemed to be enhanced by herb and shrub species, whereas nests dominated by graminoid cover tended to be more exposed. Unfortunately, due to logistical constraints, we were unable to assess possible relationships between nest concealment and nesting failure.

Nest microhabitat vegetation usually consisted of several species, primarily shrub (e.g., willow, birch), woody forbs (e.g., Lapland Rosebay), sedges (e.g., *Carex aquatilis*) and a mixture of herbaceous species. It appears that longspurs may have preferred sites with shrub and woody forb cover for nesting, but graminoid cover was not used disproportionate to availability.

Similarly, Rodrigues (1994) found shrub and forb cover was significantly higher at nest sites than random sites, but association with sedge cover was less clear.

Although Lapland Longspurs appear to be an abundant species (Hussell and Montgomerie 2002), the breeding distribution is north of regions covered by the Breeding Bird Survey (Dunn 1997). Monitoring the species across its breeding range is impractical, but trend information may be gleaned through development of several selected long-term monitoring sites. Wapusk NP may provide such a site for long-term monitoring for two reasons. First, the study site in Wapusk NP is located only 35 km east of Churchill, Manitoba, an area that has experienced substantial declines in Lapland Longspurs (Hussell and Montgomerie 2002). In contrast to declines at Churchill, survey data at the study site in Wapusk NP suggest the species is stable or has possibly increased from 1984 to 2000 (Sammler 2001). Second, the study area is experiencing increasing amounts of habitat alteration through overgrazing by Snow Geese (*Chen caerulescens*). Breeding populations of Snow Geese have experienced dramatic growth in much of the North American Arctic (Ankney 1996), leading to increased densities at tundra breeding colony sites and a corresponding degradation of vegetation by overgrazing (Kerbes et al. 1990; Abraham and Jefferies 1997; Jano et al. 1998). As Snow Geese have degraded their preferred foraging areas (i.e., salt marshes), they have started foraging in inland freshwater sedge meadows (Abraham and Jefferies 1997) such as those where this study was conducted. Snow Goose-associated habitat alteration has led to declines of some species in the Cape Churchill area (Abraham and Jefferies 1997). More specific to our study site, Lapland Longspurs were detected at lower densities in degraded freshwater sedge meadows compared to meadows that have not been impacted by Snow Geese (Sammler 2001). Thus, monitoring Lapland Longspurs at the study site in Wapusk NP may provide insight into the potential impact Snow Goose population increases may have on breeding density and reproduction of the species and other interior nesting tundra species.

Acknowledgments

We thank Murray Gillespie for logistical coordination, support, and facilitating our research at the Nester One field site while providing the opportunity to engage in this project. Nestor One is supported through the Eastern Prairie Population (EPP) Technical Section of the Mississippi Flyway Council. Steve Maxson, David Best, Kevin Doherty, Robert Nack, Jeff Dittrich, Mike Schroer, Tom Smith, Bruce Golden, and Michelle McDowell conducted nest searches across the entire study area as part of EPP monitoring efforts. We appreciate the researchers and staff at the Wapusk National Park and Churchill Northern Research Center for support, and the USGS-BRD Minnesota and Texas Cooperative Research Units for providing travel funds. We thank Geoff Holroyd and Joseph Jehl Jr. for their insightful and constructive comments on the manuscript.

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Received 23 April 2004
Accepted 17 March 2005

Novel Surface Feeding Tactics of Minke Whales, *Balaenoptera acutorostrata*, in the Saguenay-St. Lawrence National Marine Park

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Kuker, Katie J., Jordan A. Thomson, and Ursula Tscherter. 2005. Novel surface feeding tactics of Minke Whales, *Balaenoptera acutorostrata*, in the Saguenay-St. Lawrence National Marine Park. Canadian Field-Naturalist 119(2): 214-218.

Surface feeding behaviours of Minke Whales (*Balaenoptera acutorostrata*) in the mouth and fjord of the Saguenay River, Québec, were documented between June and October 2003. Several novel behaviours associated with gathering prey into dense, near-surface aggregations prior to a feeding strike were observed. To our knowledge, these behaviours have not been described in detail and may be exclusive to this area or to these individuals. A small number of known Minke Whales show strong site fidelity to the Saguenay region, providing an ideal opportunity for the study of foraging behaviour at the individual level.

Key Words: Minke Whale, *Balaenoptera acutorostrata*, St. Lawrence Estuary, foraging, surface feeding, specialization, behaviour.

The Minke Whale (*Balaenoptera acutorostrata*) is one of the smallest and most widely distributed baleen whales, averaging 7 to 10 m in length and weighing up to 9200 kg (Reeves et al. 2002). These whales generally undergo annual migrations between low latitude breeding grounds in the winter and high latitude feeding grounds in the summer. Like other balaenopterids, Minke Whales feed by swimming into a concentration of small fish or euphausiids mouth agape, then expelling a large quantity of water through their baleen while retaining and swallowing the prey.

A variety of foraging behaviours have been reported for this species. In the northeast Pacific, Hoelzel et al. (1989) reported two distinct foraging strategies: bird-association feeding, in which whales take advantage of aggregations of shoaling fish beneath feeding birds, and lunge feeding, in which whales actively gather prey prior to a strike that breaches the surface. In the St. Lawrence Estuary, Lynas and Sylvester (1988) distinguished between patch fishing and line fishing, two alternate feeding modes dependent on prey distribution. Gaskin (1982) and Edds and Macfarlane (1987) observed dynamic surface behaviours of Minke Whales in the Saguenay-St. Lawrence region but did not describe them in detail or address their function. Here, we describe and discuss the surface feeding behaviour of five well-known Minke Whales in the Saguenay Fjord, including several apparently novel manoeuvres.

Study Area and Methods

The Saguenay Fjord is a major tributary to the St. Lawrence Estuary, running 170 km southeast from Lac Saint-Jean to the north shore of the St. Lawrence River near Tadoussac, Québec. An 80 m deep sill located 18 km from the mouth of the fjord divides the Saguenay into distinct inner and outer basins, the outer reaching a maximum depth of 250 m (Schafer et al. 1990). Our study area (Figure 1) consisted of the outer basin and mouth of the fjord (48°08'N, 69°43'W), which lie within the boundaries of the Saguenay-St. Lawrence National Marine Park. Two cetacean species, Beluga Whales (*Delphinapterus leucas*) and Minke Whales, are regularly observed in the Saguenay. Larger baleen whales, including Fin (*Balaenoptera physalus*), Humpback (*Megaptera novaeangliae*) and Blue (*Balaenoptera musculus*), are occasionally seen at the river's mouth but tend to remain in the more open waters of the St. Lawrence Estuary.

Data were collected on the foraging behaviour of five known Minke Whales (individuals that were photographed regularly in the area for at least one full season prior to the study) using handheld voice recorders during 162 outings between June and October 2003. Research outings were conducted on a daily basis (weather permitting) aboard 1 to 3 small (5-7 m) rigid-hull inflatable vessels and lasted from 3 to 10 hours. Photographs were taken using SLR cameras equipped with 300 mm fixed focal lenses on 200 ISO slide film to allow identification of individuals based on dorsal fin markings and other acquired morphological traits. We focused on one identified whale at a time, documenting all surface behaviours and taking frequent Global Positioning System (GPS) positions. Duration of focal follows used in this study ranged from 15 minutes to several hours and depended largely on the continuity of feeding and on tracking conditions.

Results

A total of 32.8 hours of surface feeding data were collected from the five individuals (M1 – M5) (Figure 2) that showed strong site fidelity to the Saguenay mouth and fjord throughout the season. These whales were observed in the study area on 20, 26, 15, 47 and 31 days, respectively, from mid-June until mid-October. Opportunistic sightings data from the two previous seasons showed similar patterns of habitat use by these

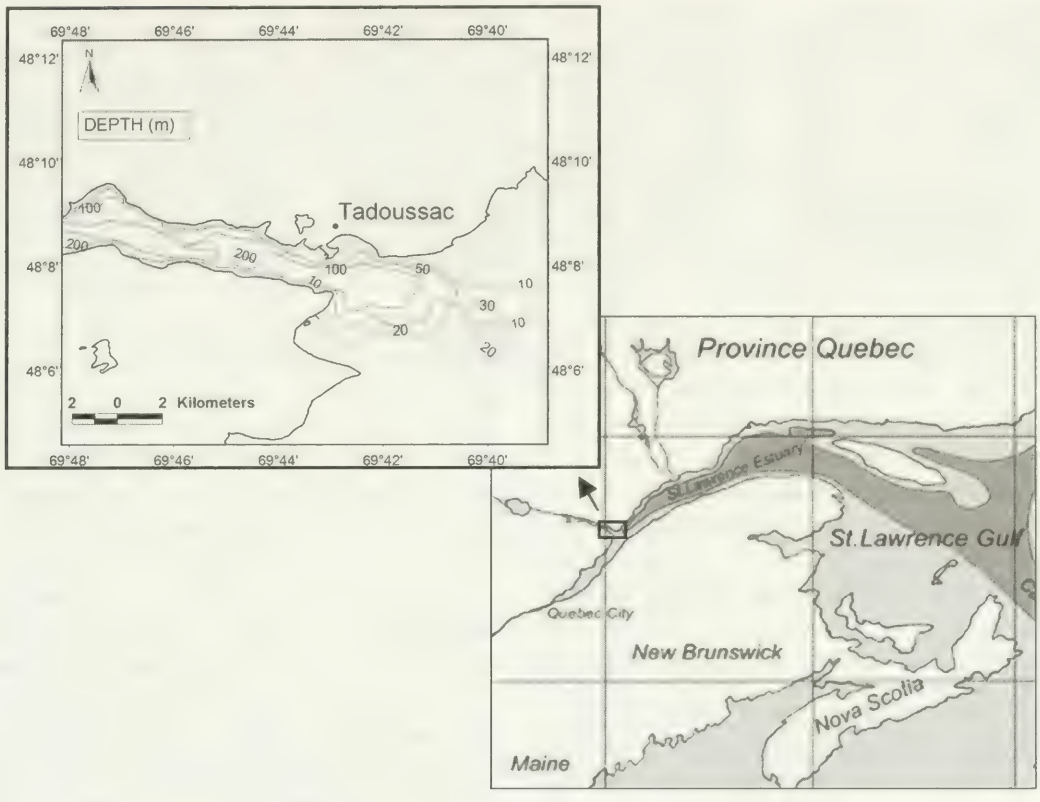

FIGURE 1. Map showing location of study site at the confluence of the Saguenay and St. Lawrence Rivers, Québec.

whales. Sightings of these individuals outside the study area were infrequent and occurred mostly near the study area boundary.

In 11 of 43 (25.6 %) focal follows, small fish (approximately 10-15 cm) were observed either (a) being displaced into the air by a feeding strike; (b) on the body surface of the whale during a feeding strike; (c) jumping at the surface of the water just prior to a feeding strike; or (d) being picked up by birds at the feeding site prior to or just after a strike. Due to extremely poor visibility in the Saguenay we were unable to identify the species. When conditions allowed us to approach the site of a recent feeding strike, the water was searched for scales or dead fish but these efforts proved unsuccessful. Prey were small shoaling fish but we can only speculate that they were most likely juvenile Capelin

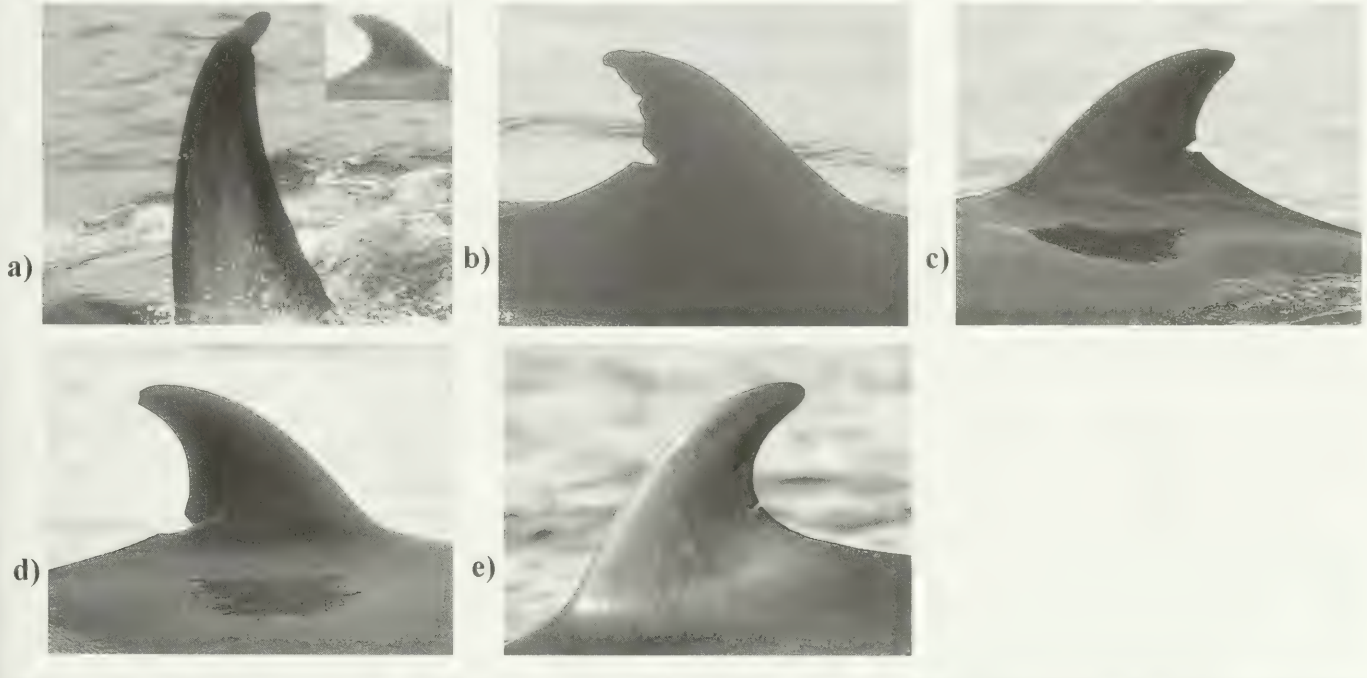

FIGURE 2. Identification photographs of the five individual Minke Whales: a) M1 (lacks dorsal fin markings but has distinct bent left fluke tip visible during lateral surface manoeuvres); b) M2; c) M3; d) M4; and e) M5.

(*Mallotus villosus*), which has been reported as the predominant prey species of Minke Whales in the Saguenay and in neighbouring areas of the St. Lawrence (Gaskin 1982; Simard et al. 2002). Sand Lance (*Ammodytes americanus*) has also been identified as prey of Minke Whales in the area (ORES unpublished data) and therefore cannot be ruled out.

The five focal whales used variations of the same foraging strategy, which involved actively gathering prey at the air/water interface using various combinations of multi-directional surface manoeuvres followed by a feeding strike at or near the surface. Pre-strike manoevures that were frequently observed included "head slaps", "chin-up blows" and "exhales on the dive". These behaviours were observed exclusively during bouts of surface feeding and were generally performed while the whale swam in a tight elliptical pattern followed by a strike at or near the centre of the ellipse.

Head Slap

Surfacing dorsal side up, the whale would slowly bring its head high out of the water at an angle of approximately 30 to 45°. As much as one third of its body became visible above the surface with ventral grooves *not* expanded and no water seen being expelled from the mouth (Figure 3a). After taking a breath, the whale would then quickly and powerfully thrust its head toward the water, creating a large splash and an audible slap as it struck the surface. Head slaps were performed on several surfacings oriented in various directions prior to a feeding strike, often at the same spot. This manoeuvre was also occasionally performed oriented laterally with the whale's right side striking the surface. Head slaps were observed on 336 occasions (22 of which were lateral) from three whales during 27 focal follows. 99.4% of these were performed by M4 and M5 (Table 1).

Chin-up Blow

Chin-up blows appeared similar to regular surfacings but were more vigorous and performed at a steeper angle than regular breaths. As the whale began to surface, it would raise its head high out of the water, breathe, and submerge in a continuous motion without a slap on the surface. This behaviour was observed frequently and was performed while oriented dorsoventrally or laterally (Figure 3b). This manoeuvre was observed on 495 occasions (219 of which were lateral) from all five individuals during 40 focal follows. Chin-up blows were the predominant pre-strike surface manoeuvre used by M1, M2 and M3 (Table 1).

Exhale on the Dive

Following a respiration, the whale would exhale as its blowholes submerged resulting in the displacement of a large volume of water into the air (Figure 3c). This manoeuvre was typically preceded by a regular blow or a chin-up blow and occasionally by a head slap. Exhales on the dive were observed on 56 occasions and were performed by only M1 and M5 during 11 focal follows (Table 1).

Discussion

The foraging behaviour of the five known Minke Whales in the Saguenay is markedly different from that observed in adjacent areas of the St. Lawrence River. For example, in the Laurentian Channel Head (LCH) located approximately 8 km east of the Saguenay mouth, Capelin are the primary prey of Minke Whales (Simard et al. 2002) and the surface manoeuvres described here were not observed in the study period. In the LCH, strong tidal currents, a stratified water column and bottom topography combine to create large areas of upwelling in which prey are forced to the surface (Simard et al. 2002). In contrast, the water in the outer Saguenay basin and mouth is well-mixed (Schafer et al. 1990), the tidal influence is lower and it appears that these whales expend a significant amount of energy gathering fish near the surface prior to a strike.

It is likely that the function of the behaviours described here is to increase prey density at the time of a strike. Precisely how this is achieved, however, is unclear and warrants further investigation. It is possible that head slaps and exhales on the dive have a combination of acoustic, mechanical and visual properties intended to stimulate an aggregation response in the prey. Aggregation has been documented as a common response of shoaling fish to "frightening" visual stimuli (Radakov 1973; Tegeder and Krause 1995), however, it has not been investigated as a response to mechanical or percussive acoustic cues such as those produced by the Minke Whales in this study.

Alternatively, it is possible that these behaviours temporarily confuse or stun the fish, restricting their movement while the whale dives to corral them by circling beneath the surface. Weinrich et al. (1992) proposed this function for lobtail feeding in Humpback Whales in the Gulf of Maine. In lobtail feeding, whales preying on Sand Lance slap the surface of the water with their flukes one to several times while diving and follow with the underwater release of bubbles leading up to a feeding strike. The response of fish to the release of bubbles was examined by Sharpe and Dill (1996), who demonstrated that bubbles can be effective in manipulating (restricting the movement) of groups of Pacific Herring (*Clupea harengus*).

TABLE 1. Pre-strike surface manoeuvres used by five known Minke Whales in the Saguenay mouth and fjord.

Individual	Surface Manoeuvre		
	Chin-up blow	Head slap	Exhale on the dive
M1	53	0	14
M2	58	0	0
M3	180	2	0
M4	19	154	0
M5	185	180	42
Total	495	336	56

FIGURE 3. Photographs of surface manoeuvres performed prior to a feeding strike: (a) head slap; (b) lateral chin-up blow; and c) exhale on the dive. Refer to text for description of these behaviours.

Other cetacean species have also been observed using surface slaps while foraging. For example, Bottlenose Dolphins (*Tursiops* sp.) have been reported using fluke slaps while foraging for single fish (Connor et al. 2000) and Dusky Dolphins (*Lagenorhynchus obscurus*) have been reported using them while feeding on shoaling fish (Würsig and Würsig 1980).

Individual Minke Whales in the Saguenay appeared to specialize in certain types of feeding strikes (for example, strikes oriented laterally or ventral side up) and surface behaviours prior to a strike. The five focal whales were often observed feeding in close proximity to other whales, each using their individual surface feeding technique, showing no signs of competition or displacement. This consistent variation made it possible on many occasions to identify individuals in the field by their "signature feeding technique" prior to obtaining an identification photograph. Lynas and Sylvestre (1988; Minke Whales) and Weinrich et al. (1992; Humpback Whales) have also reported consistent individual variation within a single foraging strategy. These studies allude to an individually learned component of foraging behaviour, which may result in the development of specialized feeding "styles".

Recently, increasing emphasis has been placed on the importance of individuality and culture in studies of behaviour and ecology (see Bolnick et al. 2003 and Rendell and Whitehead 2001). Continued studies of known Minke Whales in the Saguenay region should contribute further valuable insight on these topics. Particularly, data collected across seasons on the fidelity of these whales to the study area and on the frequency and spread of novel behaviours are of interest. Ongoing observation of these individuals should lead to an increased understanding of Minke Whale feeding behaviour and habitat use in the Saguenay, which could have important management implications for the Saguenay-St. Lawrence National Marine Park.

Acknowledgments

Funding for this project was provided by the ORES Foundation for Marine Environment Research, Switzerland. We thank the many volunteer staff and course participants of ORES for their help in data collection and processing throughout the 2003 season. Many thanks also to Larry Dill, Arielle Dylan, Siri Hakala and Stephanie Pieddesaux who provided feedback on drafts of this manuscript.

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Received 6 February 2004
Accepted 9 May 2005

First Record of the Plains Minnow, *Hybognathus placitus,* in Canada

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Sylvester, R. M., S. E. Freeling, and C. R. Berry, Jr. 2005. First record of the Plains Minnow, *Hybognathus placitus*, in Canada. Canadian Field-Naturalist 119(2): 219-223.

Seven Plains Minnows, *Hybognathus placitus,* Family Cyprinidae, were collected on 11 June 2003 from Morgan Creek, in Grasslands National Park, Saskatchewan, Canada. This collection is the first record of the species in Canada and extends the northern distribution limit of the species. Of 95 *Hybognathus* spp. collected at the site, only eight specimens were retained for positive identification because of the uncertain status of two conspecifics, the Western Silvery Minnow, *H. argyritis,* and the Brassy Minnow, *H. hankinsoni,* in Saskatchewan. Our findings should stimulate additional sampling to assess the identification and status of *Hybognathus* spp. in southwestern Saskatchewan. Accurate field identification of *Hybognathus* spp. remains an issue and collection of all specimens is recommended to accurately identify members within the genus.

Key Words: Plains Minnow, *Hybognathus placitus, Hybognathus* spp., first record, range extension, Morgan Creek, Rock Creek, Saskatchewan, Canada.

The Plains Minnow, *Hybognathus placitus,* Family Cyprinidae, is a small (≤ 15 cm; Baxter and Stone 1995), short-lived (Taylor and Miller 1990; Pflieger 1997), sexually dimorphic (Ostrand et al. 2001), herbivorous species (Page and Burr 1991; Hesse 1994). Reproduction coincides with high or receding flows in the spring and summer, after which many adults die (Sliger 1967; Taylor and Miller 1990; Pflieger 1997; Platania and Altenbach 1998). The Plains Minnow inhabits slower waters and side pools of larger, turbid streams, mainly west of the Missouri River from Montana and North Dakota, south to central Texas (Baxter and Stone 1995; Pflieger 1997).

Similar morphology and variation in meristics within *Hybognathus* spp. has made many aspects regarding identification, taxonomy, and phylogeny difficult, but efforts have been made to clarify sources of confusion throughout their range (Niazi and Moore 1962; Al-Rawi and Cross 1964; Schmidt 1994; Scheurer et al. 2003). Efforts concerning identification have proven beneficial, especially when morphologically similar species of the genus *Hybognathus* coexist. The shape of the basioccipital bone, dorsal fin profile, and number of apical scale radii are the most definitive methods to distinguish among members of the genus. The basioccipital bone appears peg-like in *H. placitus* compared to the broad process of the Western Silvery Minnow, *H. argyritis,* and the Mississippi Silvery Minnow, *H. nuchalis*, and the straight-edged process of the Eastern Silvery Minnow, *H. regius* (Page and Burr 1991). The rounded dorsal fin profile and number of apical scale radii (about 20) can be used to separate the Brassy Minnow, *H. hankinsoni,* from other *Hybognathus* spp. that have a pointed dorsal fin profile and from 8-14 apical scale radii (Baxter and Stone 1995; Pflieger 1997). When *H. placitus and H. argyritis* coexist, they often segregate ecologically, with *H. placitus* inhabiting the main channel and *H. argyritis* inhabiting protected backwaters and channel border habitats (Pflieger 1971; Welker 2000).

The Plains Minnow is listed in Colorado, Kansas, and North Dakota as a species of concern but has no status in Alberta, Saskatchewan, Montana, Wyoming, South Dakota, Nebraska, Iowa, and Missouri (Loomis 1997). Plains Minnow have been collected from the Rock Creek drainage (R. Lott, Montana Fish, Wildlife, and Parks, Glasglow, unpublished data, 2003), the Frenchman River drainage (Sylvester 2004), and several tributaries to the Missouri and Yellowstone Rivers (Gould and Brown 1966) in Montana. Plains Minnows have never been reported in Canada but absence of the species in Saskatchewan is likely due to lack of sampling effort (R. E. Jensen, Saskatchewan Environment and Resource Management Swift Current personal communication, 2003). Modifications such as dams that cause changes in the hydrologic regime, increases in water clarity, and species introductions have caused the species to be extirpated from many systems (Cross and Moss 1987; Pflieger and Grace 1987; Tomelleri and Eberle 1990; Hesse 1994). However, the species often persists where relatively undisturbed habitat conditions exist in the upper Missouri River basin.

The purpose of this study is to report the first known finding of the Plains Minnow, *H. placitus*, in Canada. Information was collected in the Rock Creek drainage, Saskatchewan, as part of an accuracy assessment of

the fish distribution models for the Aquatic Gap Analysis Program of the United States Geological Survey (Wall et al. 2002*).

Materials and Methods

Study Area

The Rock Creek drainage is located in southwestern Saskatchewan and north-central Montana (Figure 1). Rock Creek flows southerly and is a direct tributary to the Milk River, which flows into the Missouri River below Fort Peck Reservoir, Montana. Rock Creek flows through mixed-grass prairie that contains species such as Needle-and-thread Grass *(Stipa comata),* Blue Grama *(Bouteloua gracilis)*, Western Wheat Grass *(Agropyron smithii)*, sagebrush *(Artemisia* sp.), Greasewood *(Sarcobatus vermiculatus*), Prickly Pear Cactus *(Opuntia polyacantha),* Buckbrush, *(Symphoricarpos accidentalis*), willow *(Salix* sp.), Thorny Buffalo Berry *(Shepherdia azgenteas)*, Trembling Aspen *(Populus tremuloides),* and Manitoba Maple *(Acer negundo*), (Parks Canada 2002*). Major anthropogenic features such as dams have not altered the drainage in Saskatchewan but farming and livestock grazing have impacted the local landscape and some streams (Parks Canada 2002*). Three sites were sampled from 10 June 2003 to 11 June 2003 (Figure 1).

Site Selection and Fish Sampling

Site selections in the Rock Creek drainage were based on access to streams via public road crossings and contacts with personnel from the Grasslands National Park office in Val Marie, Saskatchewan. A Smith-Root Model LR-24 backpack electrofisher was the primary fish sampling gear and no block nets were used. Settings were adjusted outside of the reach until fish were sufficiently stunned and vulnerable to dip netting. Electrofishing proceeded upstream in a zigzag pattern and sampled all available habitat types. Fishes captured while electrofishing were held in a live cage, while additional sampling with a bag seine (5 or 10 m × 1.2 m, 4.8 mm mesh) was performed. Fishes collected using the seine were placed in a separate live cage. All fishes were then identified to species and counted by gear type. Specimens that could not be identified

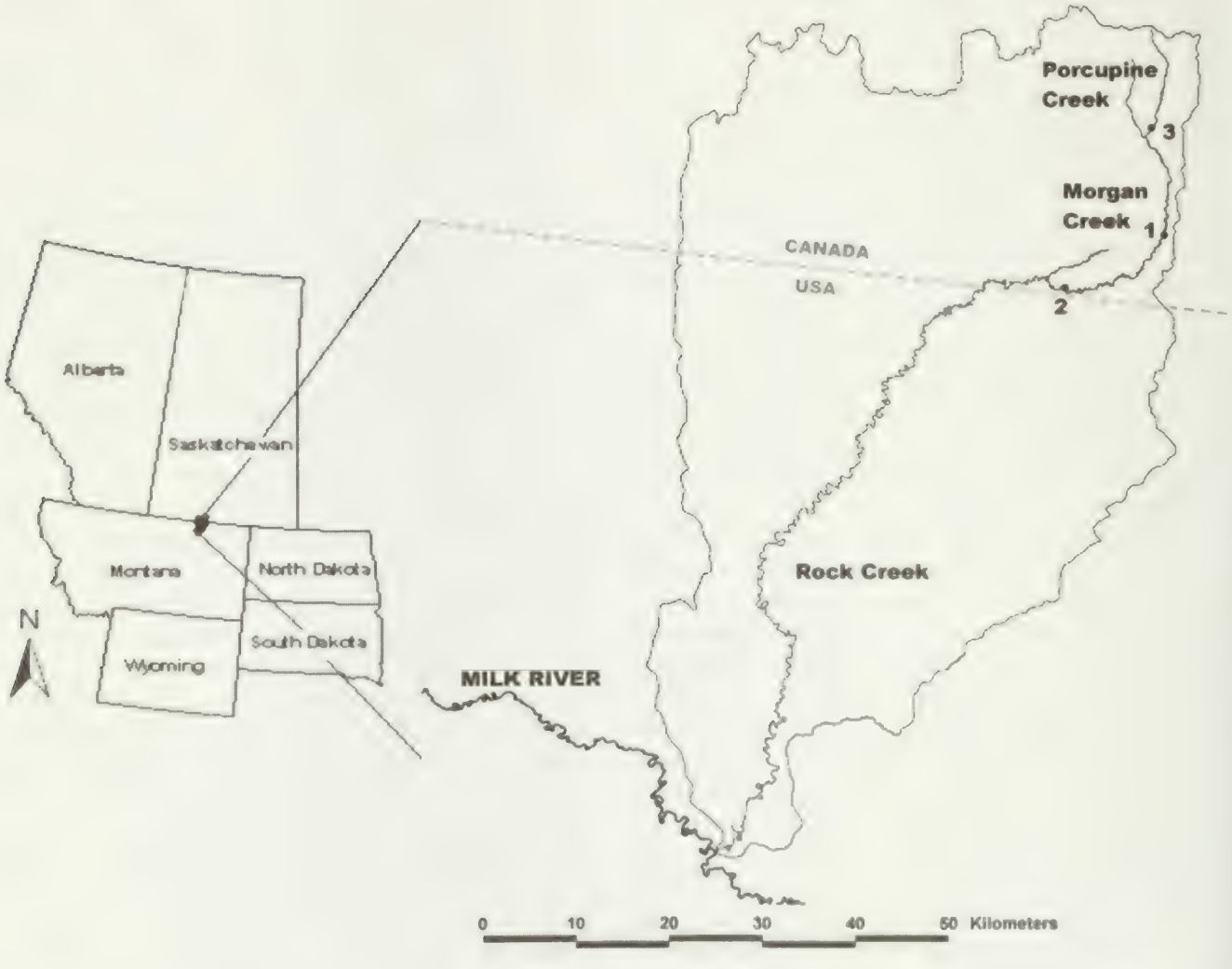

FIGURE 1. Location of the Rock Creek watershed in Canada and the United States. The dashed line indicates the international boundary between Canada and the United States and the points with corresponding numbers represent the 2003 sample locations within the Rock Creek watershed.

TABLE 1. Number of fish collected by species at each of three sites sampled in the Rock Creek drainage, Saskatchewan, Canada, from 10 to 11 June 2003.

Species	Common Name	Site 1	Site 2	Site 3
Catostomus commersonii	White Sucker	36	20	55
Couesius plumbeus	Lake Chub	5	73	118
Culea inconstans	Brook Stickleback	10	0	67
Etheostoma exile	Iowa Darter	1	0	0
Hybognathus hankinsoni	Brassy Minnow	0	1	20
Hybognathus placitus	Plains Minnow	0	7	0
Hybognathus spp.	Unknown	0	87	127
Margariscus margarita	Pearl Dace	33	69	347
Phoxinus eos	Northern Redbelly Dace	35	0	197
Pimephales promelas	Fathead Minnow	64	157	107
Rhinichthys cataractae	Longnose Dace	7	7	6

in the field were retained following collection permit stipulations, fixed in 10% formalin, and later identified in the laboratory at South Dakota State University, Brookings, South Dakota, United States.

Measurements, Meristic Counts, Sex, and Maturity

Hybognathus placitus were measured to the nearest millimeter for total and fork length and weighed to the nearest gram. Meristic counts were performed following standard methods (Al-Rawi and Cross 1964). Scales above the lateral line were counted across the back using the second row of scales in front of the dorsal fin insertion. Scales below the lateral line were counted around the belly using the second row of scales in front of the pelvic fins. Scales were collected below the dorsal fin and above the lateral line for approximate apical scale radii count (i.e., <15 or closer to 20). Sex and maturity of *H. placitus* vouchers were determined in the lab by dissection and microscopic examination of gonads. The shape and profile of the basioccipital process was also examined after dissection. Voucher specimens were added to the fish collection at South Dakota State University.

Results and Discussion

A total of 1656 fish representing 10 species were collected in our survey of the Rock Creek drainage in Saskatchewan. Pearl Dace, *Margariscus margarita,* Fathead Minnow, *Pimephales promelas*, and Northern Redbelly Dace, *Phoxinus eos.* dominated the catch (Table 1). No *Hybognathus* spp. were collected at site 1 (49°04'15.6"N 106°31'49.9"W). A total of 222 specimens were tentatively identified as *Hybognathus* spp. in the field from sites 2 (49°00'32.2"N 106°39'51.9"W) and site 3 (49°10'27.9"N 106°33'57.7"W). Eight *Hybognathus* specimens were retained for positive identification from site 2 and the remaining specimens ($N = 87$) were released because of the uncertain status of conspecifics, *H. argyritis* and *H. hankinsoni*. Based on communications with provincial fisheries personnel (R. E. Jensen, Saskatchewan and Resource Management, personal communication), the field identity of voucher *Hybognathus* spp. specimens from site 2 was believed to be *H. argyritis*. Of the eight *Hybognathus* spp. vouchers collected from site 2, 1 was identified as *H. hankinsoni* and 7 as *H. placitus,* a previously undocumented species in Saskatchewan and Canada. The pointed dorsal fin profile, peg-like shape of the basioccipital bone, and the number of apical scale radii (<15) were used to identify *Hybognathus placitus* specimens. *Hybognathus placitus* specimens (post fixation) ranged from 46 to 91 mm total length, from 44 to 84 mm fork length, weighed from 0.7 to 5.8 g, and included one mature, gravid female (Table 2). Meristic counts were similar to specimens from Wyoming and South Dakota (Al-Rawi and Cross 1964). No specimens were identified as *H. argyritis*. Known *H. hankinsoni* were collected at site 3 (males in color) and unknown vouchers from site 3 believed to be *H. hankinsoni* were verified as *H. hankinsoni* in the lab.

Habitat at site 2 appeared to represent the preferred habitat of the *H. placitus*. The majority of the site was run and pool habitat, water velocities were slow (< 0.5 m/s), substrates were generally small (< 2.0 mm), and water was turbid. Site 1 contained predominately cobble substrate, which is not the preferred habitat of *H. placitus* (Pflieger 1997). Site 3 had some boulder and cobble present due to a culvert and road crossing, was spring fed, had high water clarity, and contained bog-like vegetation and cattails (*Typha* spp.). Habitat conditions at site 3 were more suitable for the Northern Redbelly Dace, which were the second most abundant species at the site. Mean wetted width of the sites ranged from 2.26 to 3.24 m, total dissolved solids ranged from 740 to 1270 (S, temperature from 13.9 to 16.8°C, salinity from 0.3 to 0.6 ppt, specific conductivity from 699 to 1150 (S, pH from 8.4 to 8.9, and dissolved oxygen ranged from 7.6 to 10.7 ppm. Riparian vegetation was a mixture of grasses, sedges, and shrubs at all three sites.

This collection of seven Plains Minnow, *H. placitus,* in Morgan Creek, Saskatchewan represents a new species record in Canadian waters and extends the northern

TABLE 2. Post fixation measurements, meristic counts, sex, and maturity of *H. placitus* specimens collected from Morgan Creek, Saskatchewan on 11 June 2003. An asterisk identifies characteristics used to identify *H. placitus* specimens from other members of the genus.

Characteristic	Specimen Number 1	2	3	4	5	6	7
Sex	Unknown	Female	Male	Male	Male	Male	Male
Maturity	Immature	Mature	Mature	Mature	Mature	Mature	Immature
Total length (mm)	46	76	87	91	86	91	71
Fork length (mm)	44	70	79	84	79	84	66
Weight (g)	0.7	4.1	5.8	5.6	4.4	5.5	2.7
Lateral line scales	36	38	38	37	39	38	39
Scales above lateral line	13	13	13	13	13	13	13
Scales below lateral line	17	18	15	15	15	16	18
Pectoral fin rays	15	16	16	16	15	16	15
Anal fin rays	8	8	8	8	8	8	8
Dorsal fin rays	8	8	8	8	8	8	8
Dorsal fin profile*	Pointed	Pointed	Pointed	Pointed	Pointed	Pointed	Pointed
Basioccipital process shape*	Peg-like	Peg-like	Peg-like	Peg-like	Peg-like	Peg-like	Peg-like
Apical scale radii*	<15	<15	<15	<15	<15	<15	<15

distribution limit of the species. *Hybognathus argyritis*, *H. hankinsoni, H. nuchalis,* and *H. regius* have all been documented in Canada (Willock 1969; Scott and Crossman 1973; Bishop 1975; Harbicht et al. 1988; Page and Burr 1991; Nelson and Paetz 1992; Houston 1998) and *Hybognathus argyritis* is listed as threatened in Alberta. Although collection of *H. placitus* from Morgan Creek is not surprising based on other collection locations within the Rock Creek drainage and the adjacent Frenchman River drainage, it is the first known record in Canada. Presence of the species is likely due to the relatively undisturbed conditions in that portion of the Rock Creek watershed. After our survey in 2003, more detailed examination of *H. argyritis* museum specimens previously collected in Saskatchewan resulted in changes of their identity to *H. hankinsoni* (K. M. Murphy, Saskatchewan Environment and Resource Management, Swift Current, personal communication). Therefore, the presence of *H. argyritis* in Saskatchewan has not been verified to date.

Collection and preservation of all *Hybognathus* specimens may be the only way to determine the true identity and presence of *Hybognathus* spp. in Canada because accurate field identification is difficult. We recommend further investigation into the distribution, abundance, population characteristics, life history, and identification of *Hybognathus* spp. in Saskatchewan and suggest addition of *H. placitus* to the species list of both Saskatchewan and Canada. Although the species is common elsewhere, protection under the recently passed Species at Risk Act in Canada may be warranted after further investigation into the population status of the species and other members in the genus.

Acknowledgments

We would like to acknowledge R. Jensen for assisting us in the field, with landowner contacts, and for comments on this manuscript. We also acknowledge S. Wall for generating maps in this manuscript and for field assistance. We would also like to thank K. Murphy, N. Morey, C. Hoagstrom, and J. Duehr for comments on this manuscript. Additional thanks go to Grasslands National Park personnel for assistance and coordination of sampling locations and to R. G. Bramblett for verification of Plains Minnow specimens.

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Received 25 May 2004
Accepted 6 June 2005

Identification and Status of the Introduced Black Pine, *Pinus nigra*, and Mugo Pine, *Pinus mugo*, in Ontario

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Recent reference texts and other sources are contradictory regarding the spread of *Pinus nigra* and *Pinus mugo* from cultivation in Ontario. Both species have reproduced from plantings along roadsides but neither has been observed to occupy habitats in Ontario to the substantial reduction or exclusion of native species, or to substantially invade natural habitats. The more widely planted Black Pine has been recorded spreading at 24 localities throughout the eastern part of southern Ontario. Mugo Pine is reported spreading at 18 locations. Although evidently much less aggressive than Scots Pine (*Pinus sylvestris*), both Black and Mugo pines have a potential for negative impact on biodiversity in dry, rocky or sandy habitats, especially in connection with extensive plantings. A key for the identification of two-needle pines is included. Both *P. nigra* and *P. mugo* are highly variable and reported to hybridize extensively with other species.

Key Words: Black Pine, Austrian Pine, *Pinus nigra*, Mugo Pine, *Pinus mugo*, Scots Pine, *Pinus sylvestris*, spreading, invading, alien, naturalized, woody plants, Ontario.

Introduced woody plants are increasingly a source of questions relating to identification, status, distribution, and general biology. In many cases, authoritative answers to the questions are not readily available. Accurate information is important because invasive alien woody plants are a major threat to Canadian native biodiversity (Catling 1997). Some are also of importance with respect to agriculture, horticulture and/or forestry. The introduced Black Pine (*Pinus nigra* Arnold) and Mugo Pine (*Pinus mugo* Turra) provide a good example. They are both important, particularly in landscaping, but their current status, potential to spread from cultivation and their distinguishing features are not well known.

Status of Black Pine and Mugo Pine in North America

A tree to 30 m high with a rounded crown, Black Pine, also called Austrian Pine, is native to Eurasia and north Africa from Spain and Morocco east to eastern Turkey and north to Austria (Dallimore et al. 1966; Farjon 1984; Mirov 1967, map). It has been planted in North America for dune stabilization, forestry and horticultural purposes (Burns and Honkala 1990), and is currently one of the most common introduced ornamentals in the United States (van Haverbeke 2002*).

Kral (1993) does not include Black Pine in the key and species accounts in his recent work on North American pines, but he does make reference to it being naturalized in Illinois and notes characteristic features under general notes on the genus. Gleason and Cronquist (1991) do not include Black Pine in their key, but allude to it as a local escape under Red Pine. Farrar (1995) indicates that it is not spreading in Canada. Black Pine is actually much more widely escaped than these standard references suggest (Figure 1). It is naturalized throughout the Great Lakes states (e.g., Burns and Honkala 1990; Swink and Wilhelm 1994; Mitchell and Tucker 1997; Parfitt and Wade 2000; Leege and Murphy 2001) and in New England (e.g., Haines and Vining 1998, van Haverbeke 2002*), in the Pacific Northwest (Petrides and Petrides 1998) and it has been listed as an invading species in Canada (Catling 1997).

Mugo (Mugho) Pine, also known as Mountain Pine, is native to the mountains of central Europe and the Balkan peninsula. It is not included in the North American flora by Kral (1993), presumably because it had not been reported as spreading. It is widely used in landscaping and in stabilization of steep slopes. However, it was listed as spreading in Canada (Catling 1997) based on observations in Ontario.

The Ontario plant list (Newmaster et al. 1998) gives the status of both Black Pine and Mugo Pine as "ornamental", there defined as "plants that have escaped from gardens" (page 18), but this category has evidently been applied to plants that persist after cultivation in Ontario, as well as to those that spread. The authors were unaware of any case of these pines spreading (personal communication). Thus the 5-20 occurrences suggested by the provincial rank of "SE2" and "SE1" for Black Pine and Mugo Pine (respectively) refer to populations persisting after cultivation since the number of locations of plantings in Ontario is certainly in the many hundreds for both species.

Even when included in texts the two species have not been adequately compared with similar species. For example, both Japanese Black Pine (*P. thunbergii* Parlatore) and Japanese Red Pine (*P. densiflora* Siebold & Zuccarini) have escaped from cultivation in

FIGURE 1. A ten-year-old Black Pine (*Pinus nigra*) spread from a 30-year-old roadside planting along highway 7 in Hastings County, Ontario, Canada. Photo by P. M. Catling.

northeastern North America, and both could be confused with Black Pine but are not included in available keys.

A continuing assessment of the impact of these two alien pines in Ontario is desirable since they are currently being planted widely in North America. For example several million trees of Black Pine are produced annually in the United States (van Havenbeke 2002*). Assessment of impact is dependent upon a better understanding of both status and identification. The following work addresses these needs.

Methods

Literature on Black and Mugo Pines was reviewed in order to place occurrence and status within Ontario in a global context, and to provide information for identification. An identification key was prepared based on published studies and examination of specimens.

Locations in Ontario where young trees of Black Pine and Mugo Pine were growing near older plantings were recorded. Voucher specimens were collected and deposited in the Agriculture and Agri-Food Herbarium (DAO) in Ottawa.

Curators of various herbaria with significant Ontario collections including CAN, DAO, HAM, OAC, QK, TRT, TRTE, UWO, and WAT (acronyms from Holmgren et al. 1990), were contacted with a request to examine their holdings and databases for information on Black Pine spreading from cultivation. Field botanists and natural resource biologists were also contacted to find out if they had observed escaping populations.

Results and Discussion

(1) Beneficial and detrimental aspects

Beneficial Aspects

Both Black and Mugo Pines are widely recognized as valuable ornamental plantings due to resistance to pollution and high tolerance of de-icing salt spray along roadsides. Black Pine may be the most pollution-tolerant species of pine (Earle 2001*). Both species have also been recommended for use as windbreaks and as bioindicators of environmental pollution (Micieta and Murin 1998). Black Pine has also been recommended as a useful tree for tracking climatic change on a local scale (Levanic 1999; Collins et al. 2000).

Forestry Importance

Black Pine is the primary host of *Diplodia* tip rust in parts of the Great Lakes region (Vujanovic et al. 2000; Michigan State University http://www.msue.msu.edu/msue/imp/mod03/01701195.html). This rust infects native pines and other conifers. Among the recommended control measures is the use of native plantings instead of exotic plantings.

Biodiversity Importance

In Allegan County, Michigan, where 26 000 Black Pine trees were planted in a dune system between 1956 and 1972, and where the trees are now reproducing and spreading, the pine stands have been associated with a reduced cover of dune vegetation and depressed species richness (Leege and Murphy 2001). There was also evidence for modification of dune habitats at this site and the stands of introduced pines appeared to be functionally different from native tree stands. "Reproduction and naturalization of this tree in large numbers" has occurred in Illinois Beach State Park, Lake County, Illinois (Swink and Wilhelm 1994). An impoverished native seedbank has been reported in soils under Black Pine planted in natural dolomite grasslands in Hungary (Csontos et al. 1997).

Alien conifers replacing natural plant communities are a major problem in New Zealand (Hunter and Douglas 1984) where a recent study found that control of Black Pine required greater herbicide applications than were required to control other spreading conifers (Langer 1992). Both Mugo Pine and Black Pine are alien species of major concern to the conservation of natural habitats in New Zealand and extensive control programs are in effect (e.g. New Zealand Department of Conservation 2002*).

(2) General Survey Results

Both Black Pine and Mugo Pine were found to have spread from cultivation at a number of sites (Figures 2 and 3). There was no recent evidence of planting or cultivation in any of these areas. Most of these sites were old field or woodland edge habitats along roads. At many locations the young trees were of different ages from 1 to 20 years. They were not equidistant, but in patches and/or close together and near the putative parent. These observations support the conclusion that they had spread naturally from the plantings.

Remarkably, there was not a single herbarium specimen of either Black Pine or Mugo Pine in any of the collections surveyed that had a label suggesting escape. The potential for trees to be invasive is not immediately apparent because of the time that it takes to reach reproductive maturity. In the case of Black Pine, trees can reproduce as early as 15-20 years of age, or can delay until much later (Vidakovic 1974). It appears that spread of Black Pine in Ontario has occurred only over the past few decades. Good seed production in Black Pine occurs every 3-5 years (Kerr 2000). The delay as well as periodicity in ample seed production, may partially explain the lack of herbarium collections.

Nevertheless, the lack of observation, considering that many established trees that had evidently spread from plantings were over 10 years of age, suggests that invasive species are easily overlooked, and that the manpower available to document invasion is limited. Although invasive plants are a serious ecological problem, much more effort is currently devoted to documentation of rare native species.

(3) Occurrence of Black Pine in southern Ontario

Spread of Black Pine, although not frequent, has occurred over an extensive area of southern Ontario (Figures 1 and 2). The vouchers and most other trees examined were referable to var. *nigra*, which is to be expected since most of the North American plants originate from seeds collected in Austria (van Haverbeke 2002*). Those records for which vouchers are available include:

ONTARIO: HASTINGS: Hwy 7 at Madoc turnoff, 44.5250°N, 77.4176°W, old trees of similar age (30 years) and 20 young trees 2-8 years old, 22 Oct. 2001, *P. M. Catling 2001-4* (DAO); Hwy 7, E of Madoc turnoff, 44.5036°N, 77.5071°W, at this site there were about 30 old trees of similar age (30 years) and 10 young trees 1-8 years old, 22 Oct. 2001, *P. M. Catling 2001-5*, (DAO); Hwy 7 near Black River, 44.5395°N, 77.3711°W, 6 year old tree escaped from roadside plantings, 22 Oct. 2001, *P. M. Catling* (DAO). Hwy 7 near Madoc, 44.4943°N, 77.6405°W, at least 50 young plants, many seedlings, within 30 m of a large planted tree, 22 Oct. 2001, *P. M. Catling 2001-10* (DAO). OTTAWA-CARLETON: Hwy 417 and Boundary Road, 1 km S of Vars, 45.3379°N, 75.3447°W, 16 May 2002, *P. M. Catling & V. R. Brownell* (DAO). UNITED COUNTIES OF STORMONT, DUNDAS, AND GLENGARRY: S side of hwy 401 W of Cornwall, 45.0556°N, 74.8006°W, two 3-year-old seedlings under seven 30 year old planted trees, 29 Sept. 2001, *P. M. Catling* (DAO); Hwy 43, 3 km W of Avonmore, 45.1613°N, 75.0214°W, 15 May 2002, *P. M. Catling & V. R. Brownell* (DAO).

In addition to these vouchered observations, 17 sight records of young trees spread from cultivation are plotted on the accompanying map (Figure 2).

(4) Occurrence of Mugo Pine in southern Ontario

Although it is widely cultivated and capable of reproducing when only 10 years of age, there are relatively few records of Mugo Pine escaping from cultivation in Ontario (Figure 3). All three subspecies are represented by escapes in Ontario. Those records for which vouchers are available include:

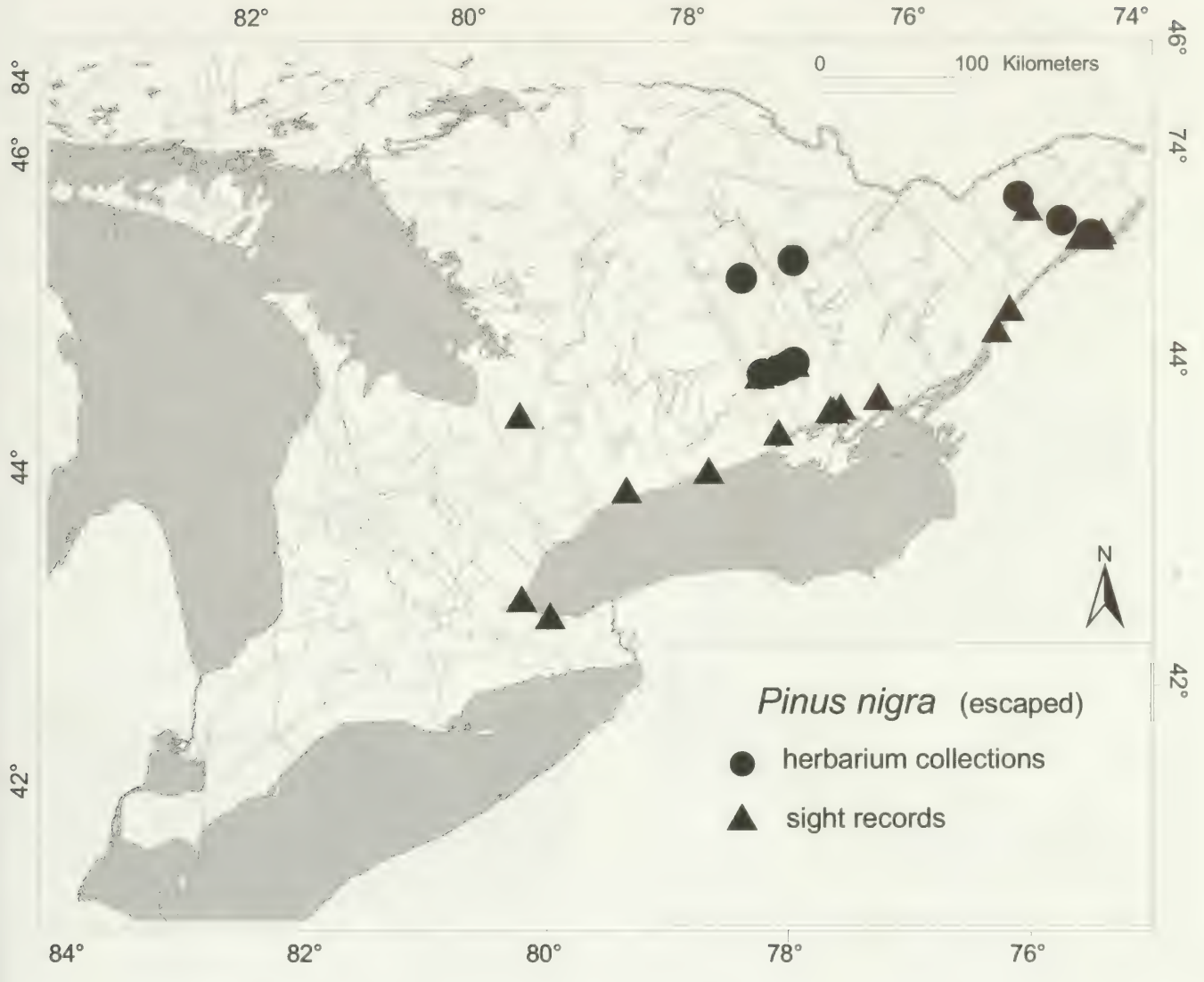

FIGURE 2. Central and eastern portions of southwestern Ontario showing locations where Black Pine (*Pinus nigra*) has escaped from cultivation. Escaped occurrences supported by herbarium specimens at DAO, Agriculture and Agri-food Canada, Ottawa, are indicated with a solid dot. Sight records of the author are indicated by solid triangles.

ONTARIO: HASTINGS: Hwy 7 east of Marmora, 44.4943°N, 77.6566°W, escaped from plantings, 22 Oct. 2001, *P. M. Catling 2001-20* (DAO *sub* subsp. *mugo*); Hwy 7 east of Marmora, 44.4943°N, 77.6566°W, from a 10 year old escaped plant with cones with apophysis hooked and recurved, accompanied by seedlings beneath a plant referable to subsp. *uncinata*, 22 Oct. 2001, *P. M. Catling 2001-11* (DAO *sub* subsp. *uncinata*); 13 km east of Marmora along Hwy 7, 44.5033°N, 77.5116°W, this branch collected from a small sapling ½ m tall, evidently escaped from planted shrubs 5 m tall within 20 m, many young plants 1-10 years old, 22 Oct. 2001, *P. M. Catling 2001-8-2* (DAO *sub* nothosubsp. *rotundata*); Hwy 7 east of Marmora, 44.4943°N, 77.6566°W, ½ year old plant, escaped from roadside plantings, 22 Oct. 2001, *P. M. Catling 2001-11*, (DAO *sub* nothosubsp. *rotundata*); UNITED COUNTIES OF LEEDS AND GRENVILLE: 2 km NE of Brockville, 44.6263°N, 75.6608°W, shrub approx. 10 years old, escaped from plantings, 27 April 2002, *P. M. Catling* (DAO *sub* subsp. *mugo*).

In addition to these vouchered observations, 13 sight records of young trees spread from cultivation are plotted on the accompanying map (Figure 3).

(5) Identification

Not all pines are easily identified. The most useful texts for identification are Shaw's (1914) well-illustrated compendium and the classic handbook by Dallimore et al. (1966). Cope (1986) also provides a key to all of the species cultivated in the northeast and a list of cultivars and their characteristics. Different authors have used different characters to distinguish the Asian species, and a comprehensive taxonomic study is needed. The following provisional key, derived from both previously published work and examination of specimens, will help to distinguish Black and Mugo Pines from similar two-needle pines including some that may have been overlooked.

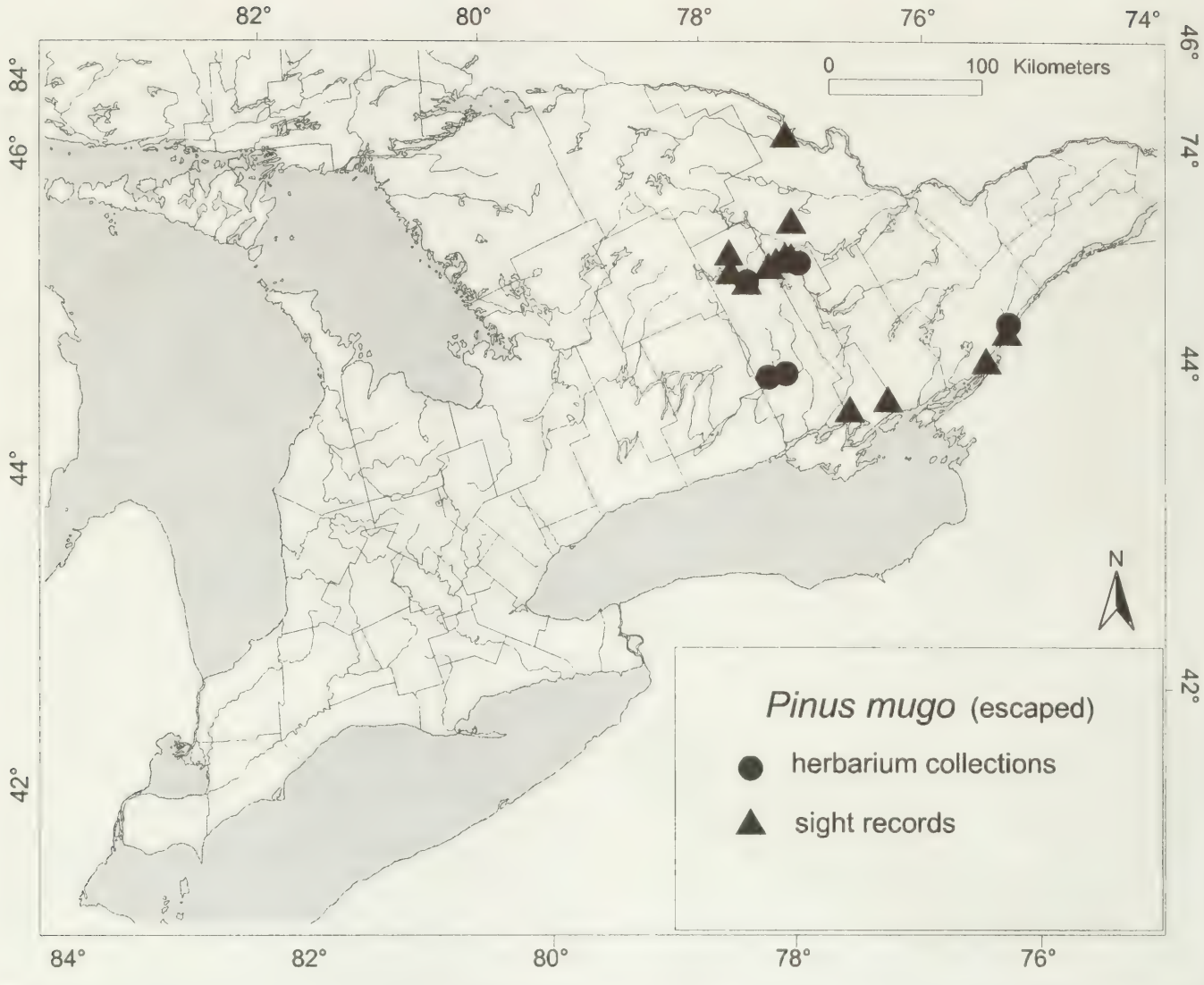

FIGURE 3. Central and eastern portions of southwestern Ontario showing locations where Mugo Pine (*Pinus mugo*) has escaped from cultivation. Escaped occurrences supported by herbarium specimens at DAO, Agriculture and Agri-food Canada, Ottawa, are indicated with a solid dot. Sight records of the author are indicated by solid triangles.

1a. Leaves 7.5-18 cm long . . . . . 2.
2a Needles snap when bent 180° (at least in *P. resinosa*); cones with or without prickles (recurved hook at centre of umbo[2]) on subterminal scales (Figure 4); resin canals marginal[4]; winter buds more or less reddish-brown . . . . . 3.
3a. Twigs glaucous; cones usually with prickles (recurved hook at centre of umbo[2]) on subterminal scales; . . . . . *Pinus densiflora* Siebold & Zuccarini, JAPANESE RED PINE
3b. Twigs not glaucous; cones without prickles (recurved hook at centre of umbo[2]) on subterminal scales . . . . . *Pinus resinosa* Ait., RED PINE
2b. Needles do not snap when bent 180°, but simply fold and either crease and remain somewhat folded, or regain their original straight appearance upon release; cones with prickles (recurved hook at centre of umbo[2]) on subterminal scales (Figure 4); resin canals median[3]; winter buds pale silvery . . . . . 4.
4a. Seed cones sessile with rounded base; terminal bud resinous; basal leaf sheath ending in a single elongated tip; scales of winter buds reddish-brown with white edges . . . . . *Pinus nigra* Arnold, BLACK PINE
4b. Seed cones with stalks and truncate at the base; terminal bud not resinous; basal leaf sheath ending in two long filaments; scales of winter buds white . . . . . *Pinus thunbergii* Parlatore, JAPANESE BLACK PINE
1b. Leaves relatively short, 2-7.5 cm long . . . . . 5.
5a. Resin canals median[3] (Figure 5) . . . . . *Pinus nigra* Arnold, BLACK PINE
5b. Resin canals marginal or submarginal[4] (Figure 5) . . . 6.
6a. Needles blue-green, often twisted; cones straight; upper bark orange-brown; twigs pale yellowish or greenish . . . . . *Pinus sylvestris* L., SCOTS PINE
6b. Needles green, not twisted; cones straight or curved; upper bark brown; twigs dark brown or greenish . . . . 7.
7a. Needles twisted; cones curved . . . . . *P. banksiana* Lamb., JACK PINE
7b. Needles not twisted; cones straight . . . . . 8.
8a. Leaf margins long-tapered and pointed at the apex; leaf sheaths early deciduous leaving pale leaf bases on older branches; seeds not winged . . . . . *P. edulis* Engelmann, NUT PINE
8b. Leaf margins abruptly tapered and somewhat rounded at the apex; leaf sheaths persistent and therefore bases not pale; seeds winged . . . . . 9.

9a. Cones 2-5 cm long, symmetrical at the base; apophysis[1] flat or slightly elevated but not recurved and hooked (Figure 6) . . . . . *P. mugo* Turra subsp. *mugo* DWARF MUGO (MOUNTAIN) PINE

9b. Cones 2.5-7 cm long, oblique at the base; apophysis prominently recurved and hooded or hooked (Figure 6) . . . . . 10.

10a. Apophysis[1] on basal part of outer side of cone hooked and recurved . . . . *P. mugo* Turra subsp. *uncinata* (Ramond) Domin, SWISS MUGO (MOUNTAIN) PINE

10b. Apophysis[1] rounded and hooded . . . . . *P. mugo* Turra nothosubsp. *rotundata* (Link) Janchen & Neumayer, HYBRID MUGO (MOUNTAIN) PINE

[1] The apophysis is the part of the seed scale that is exposed in a mature closed cone.

[2] The umbo is a protuberance on the exposed part of the scale (in an unopened cone) representing the apex of the growth of the first year. Cones of most pines take two years to mature.

[3] in middle of mesophyll between hypodermis and endodermis.

[4] outer edge of mesophyll adjacent to epidermis and hypodermis.

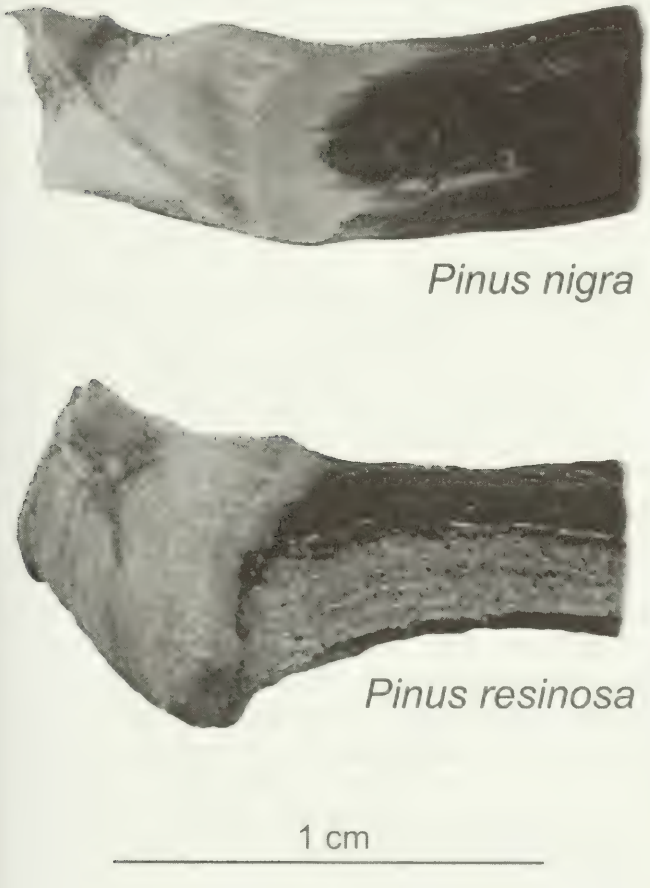

FIGURE 4. Middle cone scales of pines. Above, *Pinus nigra* cone showing terminal prickle on the umbo which is the protuberance on the scale representing the apex of first year growth, in this case elevated and pyramidal (*Kleinfeld 1774*, DAO). Below, *Pinus resinosa* cone lacking a prickle and with the umbo flattened except for small points on its lateral edges (*Marcoux s. n.*, DAO 40745). Photos by P. M. Catling.

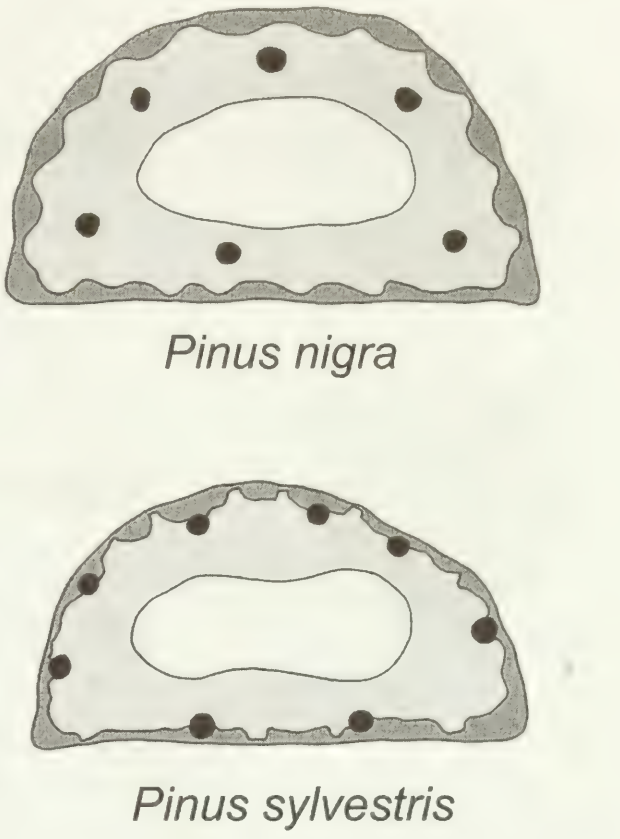

FIGURE 5. Diagrammatic cross sections of pine needles showing position of resin canals (blackened). Above, *Pinus nigra* with median resin canals. Below, *Pinus sylvestris* with resin canals submarginal and very near to or touching the epidermal tissue. Redrawn by P. M. Catling from Shaw (1914).

(6) Additional notes on identification and occurrence

1. Pinus mugo ssp. *mugo,* ssp. *uncinata* and nothossp. *rotundata* (*P. montana* Miller)

Pinus uncinata Miller ex Mirbel is sometimes placed in synonymy with *Pinus mugo* Turra, or treated as a variety (*Pinus mugo* var. *rostrata* Hoopes), but it has most recently been treated as a subspecies. It grows as a tree to 25 m tall with cones 5-7 cm long. The tree (ssp. *uncinata*) and shrub (ssp. *mugo*) have hybridized extensively (Gaussen et al. 1964) and the hybrids have been referred to *P. mugo* nothossp. *rotundata* (Link) Janchen & Neumayer. Apart from forms only the three infraspecific taxa (*mugo, uncinata* and *rotundata*) are recognized in Christensen's (1987) classification which reduced *P. mugo* from 16 species with 91 varieties.

The cones of *P. mugo* are essentially sessile whereas those of *P. sylvestris* are stalked. *Pinus mugo* and *Pinus sylvestris* hybridize in their native range to produce *Pinus* ×*rhaetica* Brügger (Christensen 1987). Since both occur together as escapes along roadsides in Ontario, there is a possibility for this hybrid to occur here as well. It possesses characters of *P. sylvestris*

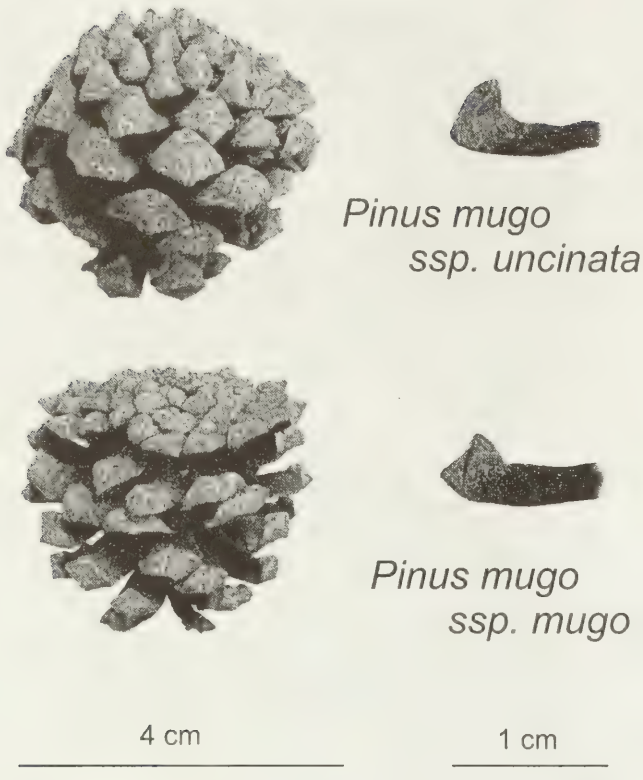

FIGURE 6. Cones and cone scales of *Pinus mugo* showing apophyses (exposed portion of seed scale). Above, ssp. *uncinata* cone (left) and lateral view of scale (right) showing hooked and recurved apophyses (*Catling 2001-11*, DAO). Below, ssp. *mugo* cone (left) and lateral view of scale (right) showing apophyses elevated but not recurved and hooked (*Catling 2002-1*, DAO). Photos by P. M. Catling.

including the peeling bark, but the bark is more greyish-brown than orange and the leaves may be either bright green as in *P. mugo*, or glaucous green as in *P. sylvestris*. As in *P. mugo* the umbo is bordered by a black, grey or dark brown ring (Christensen 1987).

2. Pinus nigra

Pinus nigra has been more divided into infrataxa (e.g., Bailey 1948; Vidakovic 1974) than other pines with similar levels of variability (Earle 2001*). The major pattern of variation in Eurasia involves eastern and western groups (e.g., Dallimore et al. 1966; Scaltsoyiannes et al. 1994):

1a. Needles stout and rigid, 1.5-2 mm thick . . . . . subsp. *salzmannii* (Dunal) Franco (eastern)

1b. Needles slender and flexible, 0.8-1.5 mm thick . . . . . subsp. *nigra* (western)

The western ssp. *nigra* includes 3 varieties (Earle 2001):

1a. Needles 6-14 cm; bark on old trees greyish . . . . . var. *nigra*, AUSTRIAN PINE

1b. Needles 8-18 cm; bark on old trees orange-pinkish . . . . . 2.

2a. Cones yellowish, 5-10 cm long . . . var. *caramanica* (Loudon) Rehder, TURKISH PINE

2b. Cones greyish, 7-12 cm long . . . . . var. *pallasiana* (Lambert) Aech. & Graebn., CRIMEAN PINE

Plants of *Pinus nigra* that are 1-4 years old have needles that are much shorter, often 4-6 cm long, than those of older plants, which are usually over 7.5 cm long. Consequently *P. nigra* appears twice in the preceding key to species where the first couplet distinguishes species on the basis of needle length. Among the few and rather rare dwarf forms of *P. nigra* is cv. *hornibrookiana*, a shrubby plant with stiff lustrous dark needles less than 6 cm long (illustrated by Bailey 1948, plate IX). The median resin canals readily separate the latter cultivar or a young short-needled plant of *P. nigra* from *P. mugo*.

The needles of the Black Pine group that do not snap when bent and the presence of spines on the cone scales readily distinguish it from Red Pine with which it is most likely to be confused. With respect to its separation from *P. thunbergii*, different authors have emphasized different characters. Earle (2001*) suggests that the tomentum on the young elongating shoots is distinctive in *P. thunbergii*, but Dallimore et al. (1966) describe the young shoots as glabrous. Young plants of Black Pine with relatively shorter needles can still be distinguished from other short-needled species by the position of the resin canals as indicated in the key. In the eastern part of their natural range *P. nigra* and its relatives (including *P. thunbergii*) require more taxonomic study. *Pinus ponderosa* Douglas (Ponderosa Pine) is sometimes sold and planted in Ontario as *P. nigra*, but the former is readily distinguished by leaves usually in fascicles of 3 and by the much more prominent prickles (1-2 mm in length) on the middle and upper cone scales.

Natural hybridization between Black and Japanese Red pines has been reported in southern Michigan (Wright et al. 1969). The hybrids were reported to grow more rapidly than either parent. At age 4 years they could be identified by needles of intermediate stiffness and sharpness (between the stiff, sharp needles of *P. nigra* and the flexible, more blunt needles of *P. densiflora*). Presence of 3-needled fascicles was also characteristic of the hybrid. The young hybrid trees are also identifiable by their terminal buds which are darker brown than in Black Pine, and by intermediacy in position of resin ducts. The Black-Japanese Red pine hybrid is considered commercially valuable for both timber and roadside planting. In Europe natural hybrids have formed with *P. mugo* and *P. sylvestris* (e.g., Vidakovic 1958). Many other hybrids have been produced to create superior trees for lumber production (van Haverbeke 2002*).

Trees of *Pinus nigra* reach 6-10 m in height and 10-15 cm dbh when 15-20 years of age and many produce seed as early as age 15. They are reported to have growth rates similar to that of the more widely planted and native *P. resinosa* on some sites (van Haverbeke 2002*). They are not necessarily superior to *P. resinosa* outside of the special circumstances of roadsides (Morrow 1975). *Pinus nigra* has been recommended as an

alternative to *P. resinosa*, where the latter is particularly subject to European pests (Wright and Bull 1962).

3. Pinus edulis

Also treated as *Pinus cembroides* var. *edulis*, this taxon is culitivated for its edible seeds often called "piñons". It is widely cultivated outside its native range which is the semi-desert of the southeastern United States. The native range includes climatic zones similar to those of southern Ontario. It is occasionally introduced into remote natural settings such as the Kaladar Jack Pine barrens in Ontario (approximately 44.5333°N, 77.1500°W). Trees begin to bear cones when 25 years old and 3 m tall.

4. Pinus resinosa

Red Pine is native to southeastern Canada and the adjacent United States. It is one of the most widely planted pines in Ontario, as individual trees, in small plots and in plantations. It spreads readily from plantings, but to a much lesser extent than *Pinus sylvestris*. In addition to the key characters, the reddish flaky bark is distinctive.

5. Pinus sylvestris

Scots Pine, also called Scotch Pine, is native to Eurasia. It frequently spreads from cultivation in Ontario forming dense stands that exclude native species. The yellowish or light brown branches and glaucous needles of young trees are distinctive. The orange bark of the upper trunk and outer branches are distinctive in older trees.

6. Pinus densiflora

A tree to 40 m tall, *P. densiflora* is native to Japan, Korea, China and Russia. It is very similar to *P. sylvestris* from which it can be distinguished by longer, dull green (but not glaucous) leaves, glabrous branchlets and larger cones. The conelets of *P. densiflora* are erect instead of reflexed as in *P. sylvestris* (Shaw 1914). The 2-4-year-old branches are without exfoliating scales unlike those of *P. nigra*, *P. resinosa* and *P. thunbergii* (Bailey 1948). *Pinus densiflora* is now widely planted in Europe and North America.

7. Pinus thunbergii

A tree to 43 m tall, *P. thunbergii* is native to Japan and southern Korea. Its pale and rigid leaves are useful in identification. The fresh cones are brown in *P. thunbergii* instead of brownish-yellow as in *P. nigra* (Shaw 1914). *Pinus thunbergii* also has fewer and larger cone scales than *P. nigra*, but is apparently closely related to the latter species. It has also been separated from *P. nigra* by its tendency to have yellow or orange twigs (as in *P. resinosa*), instead of brown or dark grey twigs (e.g., Bailey 1948).

8. Pinus banksiana

A tree to 30 m tall, *P. banksiana* is native to the boreal and mixed forest regions of Canada excepting the western cordillera. It is readily distinguished by crooked branches, relatively short needles and curved cones. It has been frequently established in plantations on dry sites.

(7) Prospects

At the present time neither Black or Mugo pines are seriously affecting native biodiversity. Naturally established individuals often exist in small numbers and mostly along roadsides and in vegetation comprised of other alien species. Although evidently less aggressive than the introduced Scots Pine (*Pinus sylvestris*), both Black and Mugo pines have a potential for negative impact on biodiversity in dry, rocky or sandy habitats, especially in connection with extensive plantings. Black Pine in particular has been shown to grow better in North America than in its native range, to reduce native biodiversity and cover, and requires relatively high levels of herbicide application to control. As a result of its superficial similarity to native species, it may be overlooked as a problem, thus leading to management difficulties that would not exist if it was identified as a risk at an early stage.

Acknowledgments

Peter Uhlig and Mike Oldham helped in gathering information on the status of pines in Ontario and their identification. W. J. Cody and J. Cayouette provided useful comments on the manuscript. G. Mitrow assisted in obtaining data.

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Received 7 January 2003
Accepted 26 April 2005

A Potential for the Use of Dragonfly (Odonata) Diversity as a Bioindicator of the Efficiency of Sewage Lagoons

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Catling, Paul M. 2005. A potential for the use of dragonfly (Odonata) diversity as a bioindicator of the efficiency of sewage lagoons. Canadian Field-Naturalist 119(2): 233-236.

In order to determine whether a relationship existed between water quality and odonate fauna in sewage ponds, data were gathered at each of six ponds of similar construction and equal size and depth in an adjacent series of improving water quality at a lagoon system near Embrun in eastern Ontario. Numbers of nymphs of different species of Odonata were recorded in spring and fall, and similar data was collected on adults in June and July. The data on species presence and abundance for each of three pairs of cells in the sequence was then compared with the corresponding chemical data which included biological oxygen demand, total phophorus, total nitrogen and suspended solids. Water quality improved through the system and species diversity in the final ponds was twice that of the ponds receiving wastewater. Numbers of individuals also increased through the system. Occurrence of *Anax junius*, *Enallagma civile* and *Ischnura verticalis* alone was associated with poorer water quality. Higher diversity including *Lestes disjunctus*, *Leucorrhinia* spp. and *Erythemis simplicicollis* , indicates higher water quality. A potential exists for Odonata species diversity, numbers of individuals and occurrence of particular species to be used as a bioindicator of water quality and a means of evaluating efficiency of a lagoon system. Advantages include data that reflects a time period rather than a point in time and also low costs.

Key Words: Odonata, dragonflies, bioindicator, biodiversity, sewage lagoons, pollution, water quality, Ontario, Canada.

Sewage lagoons, a cost-effective form of waste treatment, are widespread in Canada, especially in sparsely populated regions. Many of the present lagoon systems in eastern Canada were developed after 1950 (Manoharan 1985). They soon became recognized as a distinctive environment resembling western prairie sloughs in their high productivity and biological composition. Lagoon systems are characterized by a series of pools of increasing water quality from the first receiving water with raw sewage to the last receiving water that has had substantial treatment. This sequence provides an opportunity for assessing association of aquatic species and abundance in relation to water quality. Such information can be applied to an assessment of the efficiency of a lagoon system.

Biodiversity and numbers of individuals of dragonflies have been shown to be related to water quality worldwide (e.g., Watson et al. 1982; Takamura 1991; Corbet 1999) and in Canada (Lefort and Catling 1998), but their potential use in evaluating sewage lagoon systems has not been studied. A preliminary investigation (Catling 2004) suggested a relationship between water quality and dragonfly species presence and abundance in sewage lagoons and identified species groups representative of good and poor water quality. Although useful, this study was based indirectly on water quality through a demonstrated correlation with water clarity. The present work adds to this by elucidating the direct relationship with specific values of water quality parameters in a series of sewage ponds. The objective was to further explore the extent to which dragonflies have a potential use in evaluating the efficiency of sewage lagoon systems.

Methods

Each of six ponds of similar construction and equal size and depth in an adjacent series of improving water quality were sampled at a lagoon system near Embrun (45.2767°N, 75.2359°W) in eastern Ontario. Numbers of nymphs of different species of Odonata were recorded in spring and fall (15 October 2001 and 17 April 2002), and similar data were collected on adults in summer (26 June 2002 and 18 July 2002). The data on species presence and abundance for each of three pairs of cells in the sequence were then compared with the corresponding chemical data which included biological oxygen demand (BOD), total phophorus (TP), total nitrogen (TN) and suspended solids (SS). The data included three measurements (fall 2001, spring 2002, fall 2002) of each parameter from each of the six sewage ponds. All measurements (mg/L) were made at Accutest Laboratories in Ottawa on behalf of the township of Russell. These measurements were averaged to provide an indication of overall conditions. Since adjacent sewage ponds and even parts of ponds appear to vary greatly in water chemistry due to the time of year, amount of input and other factors relating to speed of breakdown, the point samples can only be considered to indicate a trend in the sequence. To compensate for variation, chemical data in each adjacent pair of cells (in the sequence of six) were averaged. This averaging also accounted for the bypassing of cells 1, 3 and 5 during periods of heavy use, making certain sequential pairs of cells similar.

Nymphs were sampled with 50 scoops of a net at each of the six ponds on each of two visits. Thus it was the potential and successful overwintering nymph pop-

TABLE 1. Number of nymphs of species of Odonata found in spring (S), fall (F) and the total (T) for three pairs of cells at the Embrum lagoon system.

Species	1,2			3,4			5,6		
	S	F	T	S	F	T	S	F	T
Anax junius	–	2	2	197	80	277	10	35	45
Enallagma civile	–	50	50	24	210	234	100	265	365
Enallagma cyathigerum	–	–	–	–	–	–	60	37	97
Erythemis simplicicollis	–	–	–	–	–	–	1	–	1
Ischnura verticalis	10	150	160	34	135	169	20	160	180
Lestes disjunctus	–	–	–	–	–	–	–	8	8
Leucorrhinia proxima	–	–	–	–	–	–	20	–	20
Leucorrhinia intacta	–	–	–	–	–	–	3	–	3
Libellula quadrimaculata	–	10	10	–	–	–	5	5	10
Libellula pulchella	–	–	–	–	–	–	7	3	10

TABLE 2. Total number of adults of species of Odonata recorded on two summer visits to the Embrun lagoons.

Species	1,2	3,4	5,6
Anax junius	5	30	55
Enallagma civile	5	400	795
Enallagma cyathigerum	–	80	60
Epitheca cynosura	–	6	3
Ischnura verticalis	10	190	242
Lestes disjunctus	–	–	1
Tramea lacerata	–	–	1

ulations that were sampled. Sample points were approximately equally distributed around the edges of the lagoons. The nymphs were identified using the keys in Walker (1953). The heavily mottled body, long-pointed caudal lamellae and eyes with horizontal black lines, made the identification nymphs of Eastern Forktail (*Ischnura verticalis*) relatively simple. Nymphs of the species of bluets (*Enallagma*) were less easily identified. They were assigned to taxa in the field based on characteristics of the caudal lamellae evaluated with a 15× hand lens. In cases where the numbers of larvae exceeded a hundred, species composition was often based on microscopic examination of 20–50% of the total identified in the field. Approximately 95% of field identifications were correct. Adults were surveyed over a period of two hours on each of two dates with approximately 20 minutes spent at each of the six ponds.

Results and Discussion

At the Embrun lagoon system it is clear that biological oxygen demand, total nitrogen and suspended solids decrease from the lagoons receiving wastewater to the final "polishing ponds" that release treated effluent back to surface water drainage (Figure 1). Total Phosphorus is highest in the mid-portion of the system, possibly due to gradual release from organic matter and then precipitation in the middle part of the process. The water in the final pool of the Embrun system is relatively clean and well below the 25 mg/L compliance criteria for biological oxygen demand (BOD) and suspended solids (SS). Associated with this increase in water quality through the series of ponds, both the numbers of individuals and the numbers of species of dragonflies increases (Tables 1 and 2, Figure 2). Numbers of individuals of nymphs were not that much higher in the final ponds than in the middle ponds in the series (Figure 2), but there were large numbers of the few species present. The increase in diversity of species and numbers of individuals with improving water quality supports similar findings in studies comparing polluted and non-polluted waters (e.g., Watson et al. 1982; Takamura 1991; Lefort and Catling 1998; Corbet 1999).

Northern Spreadwing (*Lestes disjunctus*), whitefaces (*Leucorrhinia* spp.) and Eastern Pondhawk (*Erythemis simplicicollis*) were found only in the ponds with superior water quality as was the case in a preliminary study of several eastern Ontario lagoon systems based on correlates of water quality rather than actual values (Catling 2004). In addition the three species characteristic of the lowest water quality in that correlative study were same three found alone in the poor quality ponds at Embrun; i.e., Common Green Darner (*Anax junius*), Familiar Bluet (*Enallagma civile*) and Eastern Forktail (*Ischnura verticalis*). Data are insufficient to give an accurate indication of the tolerance limits of

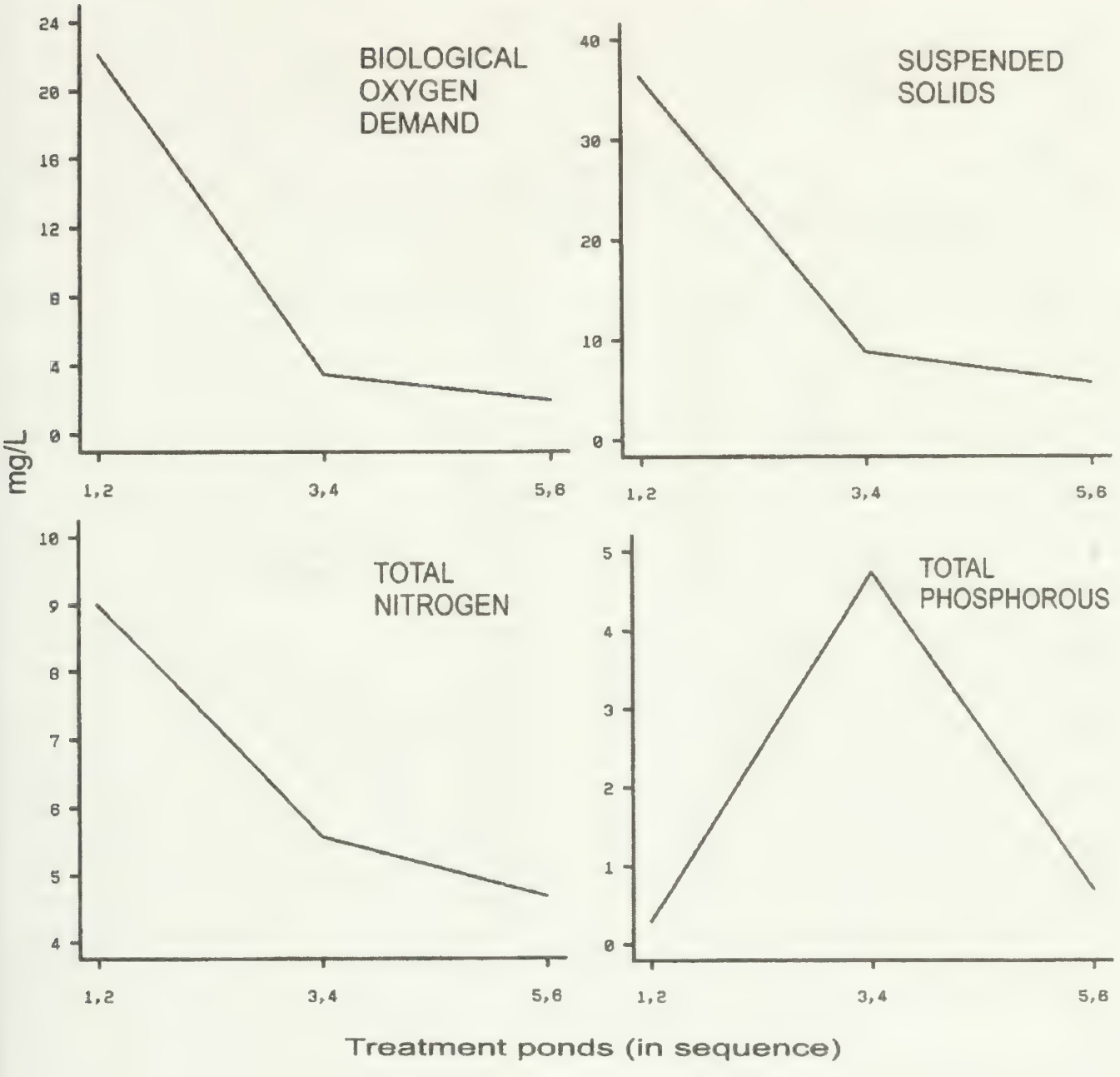

FIGURE 1. Mean measurements of chemical parameters at Embrun, eastern Ontario, based on sampling of the six ponds on three separate dates (22 October 2001, 26 February 2002, 15 October 2002).

different species, but average chemical conditions associated with dragonfly populations can be estimated from Figures 1 and 2.

The first lagoons were poorer in species diversity and numbers in the spring than in the fall possibly due to decreased rate of decomposition and reduced oxygen during the winter months resulting in extreme conditions that eliminated much of the fauna in the initial ponds. Nymphs in early spring may provide the best indication of water quality due to direct association with water following a period of stress. However, adults appear to be able to recognize water quality and some species tend to occur only on the cleaner ponds (Figure 2). Overall the increase in species diversity in the final ponds is twice that of the ponds receiving wastewater.

This study suggests that the improving water quality in a series of sewage ponds is reflected by increasing odonate species diversity and increasing numbers of individuals of both aquatic larvae and aerial adults. The use of the indicator species is particularly promising and can be used in conjunction with diversity and numbers. The potential to use dragonflies as a bioindicator of the efficiency of sewage ponds requires additional study to confirm this suggestion over a broad area. It has two obvious advantages over chemical tests: (1) It includes reference to a time period (the larvae living in the pond for at least several weeks) rather than a single chemical sample at one particular point in time that may or may not be representative of conditions over the longer period. (2) It is inexpensive and can be done at most times of year using

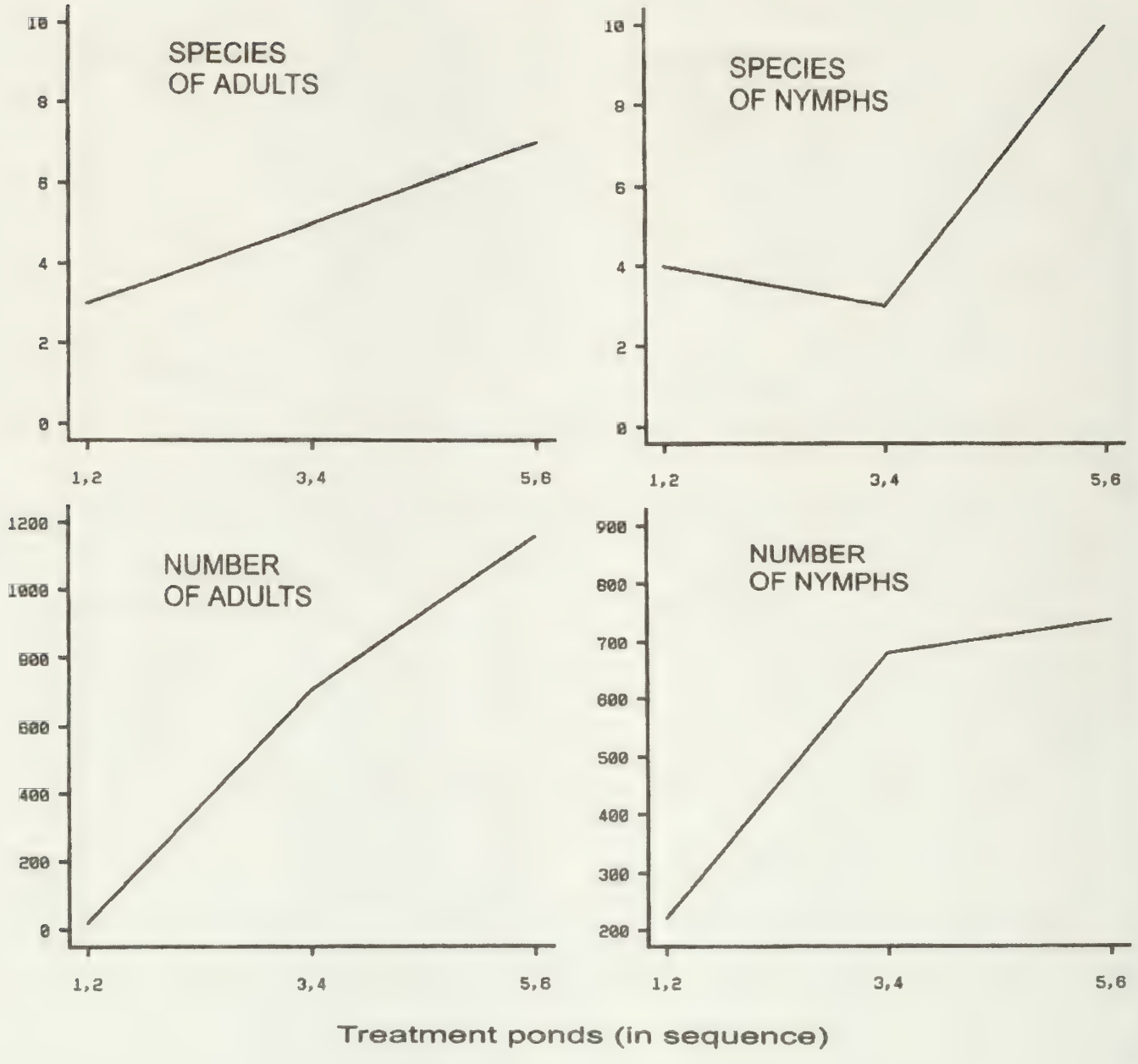

FIGURE 2. Numbers of species and individuals of both larval and adult Odonata a the Embrun lagoons.

either mature larvae or adults, or both depending on the time.

Acknowledgments

Craig Cullen, superintendent of public utilities for the township of Russell, assisted by providing extensive information on the lagoon systems at Embrun.

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Received 30 April 2003
Accepted 26 April 2005

Invasive Scots Pine, *Pinus sylvestris*, Replacing Corema, *Corema conradii*, Heathland in the Annapolis Valley, Nova Scotia

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Catling, Paul M., and Susan Carbyn. 2005. Invasive Scots Pine (*Pinus sylvestris*) replacing Corema, *Corema conradii*, heathland in the Annapolis valley, Nova Scotia, Canadian Field-Naturalist 119(2): 237-244.

Examination of air photos from 1930, 1970 and 2002 revealed stands of the European Scots Pine (*Pinus sylvestris*) invading remnants of natural Corema (*Corema conradii*) heathland in the Annapolis valley. To document the impact of the introduced pines, four natural habitats were compared with two adjacent habitats already invaded by the pines. All surveyed habitats had been dominated by Corema heath based on air photos taken in 1930. Twenty 1 m^2 quadrats were used to record presence and cover of vascular plants at each site. The invasive alien pines reduce the native cover to 12%. Vascular plant biodiversity is reduced to less than 42% and the cover of the heathland dominant, *Corema conradii*, is reduced from over 100 % to less than 2%, with *Deschampsia flexuosa* becoming the dominant species. The modified ecosystem and loss of biodiversity has economic impacts through loss of pollinators of agricultural crops and loss of germplasm of native crop relatives.

Key Words: Scots Pine, *Pinus sylvestris*, Corema, *Corema conradii*, invasive, alien, heathland, barrens, Nova Scotia, Canada.

Scots Pine (*Pinus sylvestris* L.) is native to much of Europe and northern Asia and has been introduced and become naturalized throughout the temperate regions of the world. It is the most widely distributed of the world's pines (e.g., Farrar 1995) and is used for landscaping, shelterbelts, soil stabilization and general reforestry purposes. Not only is it used for all of these purposes in Canada but is also cultivated extensively for use as Christmas trees. In some parts of Canada it has spread from cultivation and invaded natural habitats (Catling 1997).

One of the places where a significantly deleterious invasion is occurring is in the remnants of the heathland ecosystem dominated by Corema (*Corema conradii* Torr.) on the sand plains of the Annapolis valley, Nova Scotia. These threatened plant communities are already deteriorating due to succession of the vegetation to forest apparently as a result of the lack of fires. Mesic sites are the most susceptible. Although native woody vegetation is slow to invade the drier sites, Scots Pine has proved to be a very aggressive invader that forms dense stands that exclude most other plant species.

Here we document the conversion of natural heathland to Scots Pine wood and provide an indication of the vegetation changes that have likely occurred through a comparison of invaded and non-invaded sites. This will permit a better understanding of vegetation dynamics in the heathland and will provide the information needed for effective management.

Methods

Documenting invasion of Scots Pine

Through examination of air photos from 1930, 1970 and 2002 aerial surveys (Figure 1) and examination of sites in 2003, specific areas of heathland that have been invaded by Scots Pine can be clearly identified providing an opportunity to assess the impact of the invading pines. These areas have evidently not been subject to other unnatural disturbances so that the differences in vegetation between them and the adjacent heathland are due to Scots Pine invasion. The stands of Scots Pine on the heathland appear to have originated from seed dispersed from trees planted around buildings or in plantations nearby. Isolated older Scots Pines 10-30 years of age produce seed readily and are frequently surrounded by younger trees 1- 15 years old which grow with further recruitment to form a dense stand within another 15-20 years.

Assessing impact of Scots Pine

The conversion of natural heathland to Scots Pine and specifically the impact of Scots Pine was assessed through comparison of invaded heathland with adjacent natural heathland with various amounts of native tree cover. The study area was located at approx. 45.0166°N, -64.8833°W between Auburn and Kingston in Annapolis County, Nova Scotia. On 26 June 2003, presence and cover of vascular plant species was recorded in six habitats within an area that was essentially open heathland 50 years earlier based on aerial photographs on file at Nova Scotia Department of Natural Resources (Figure 1). Of the six habitats sampled four were dominated by native species of open heathland and two were dominated by Scots Pine which had invaded parts of the heathland. The two open heathland sites described were immediately adjacent to the Scots Pine stands and the introduced pines were extending into the open heathland area. The two heathland sites with Red Pine (*Pinus resinosa* Ait.) had

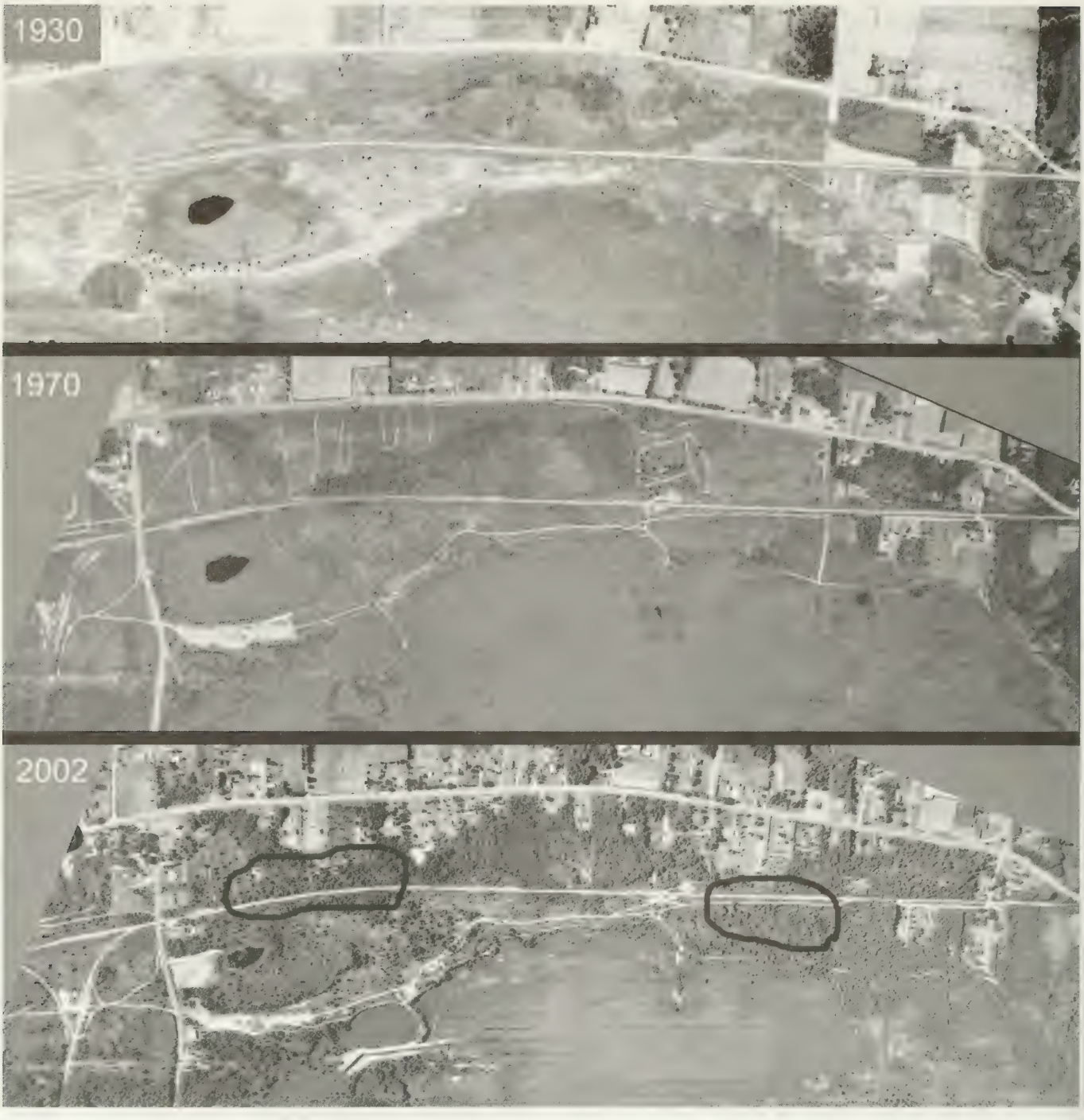

FIGURE 1. Airphotos showing a portion of the heathland on the west side of Auburn (approx. 45.0166° N, - 64.8833° W) in 1930, 1970 and 2002. The stands of *Pinus sylvestris* where ground flora was evaluated are delineated with a black line on the 2002 photo. In 1930 heathland existed where these stands now occur. The Scots Pine stands were just starting to develop in 1970.

adjacent open heathland. All sites sampled were evidently Corema-dominated heathland in 1930 (Figure 1).

Site 1, an open heathland approx. 90% open in aerial view with scattered White *(Pinus strobus* L.), Red, and Scots pine and site 5, the adjacent Scots Pine stand was located at 45.0107°N, 64.8960°W. Site 2, the other open heathland, also approx. 90% open, and site 6, the adjacent Scots Pine stand was located at 45.0157°N, -64.8803°W. Site 3, an open heathland, 60% open in aerial view, with Red Pine 50 years old was located at 45.0014°N, -64.9419°W. Site 4, the semi-open 60-70 year-old Red Pine stand, approximately 20% open in aerial view was located at approximately 44.9916°N, 64.9750°W.

At each site the habitat was delineated and within it a transect was selected at random using a compass line derived from random numbers. Presence and cover was recorded for each species in each of 20 one m^2 quadrats at 5 m intervals along the transect line. Cover was estimated as ½ the surface area of each species rather than a simple aerial view and thus could exceed 100% of the surface of the square metre sampled. This method

FIGURE 2. Natural heathland on the west side of Auburn (approximately 45.0166° N, 64.8833° W) with ground cover dominated by Corema (*Corema conradii*) and scattered native Red Pine (*Pinus resinosa*).

provided a maximally accurate description of biomass. Species up to 2 m tall (including trees) were recorded. In a very few cases where a large tree trunk was in a selected quadrat, the position of the quadrat was moved (up to ½ m) to avoid the trunk. For comparison, the mean frequencies and covers for each pair of communities was calculated and expressed as a percentage of that of the open heath. Voucher specimens are in the collection of Agriculture and Agri-Food Canada in Ottawa (acronym DAO).

Results and Discussion

Native Red Pine and White Pine exist as scattered trees in open heathland (Figure 2) and the mature trees are rarely accompanied by nearby saplings and seedlings, presumably due to difficulty of establishment and specific requirements such as suitable mineral substrate. In contrast mature Scots Pines are usually surrounded by saplings and seedlings, many of which survive to form a dense stand, and the trees can establish in organic soils.

Red Pine forming stands in open heath (Figure 3) may result in a reduction of low heathland cover to 47.5%, as well as a reduction of diversity to 75.7% (Tables 1 and 2). The dense stands of Scots Pine that develop can cause a much greater reduction of cover and biodiversity with cover reduced to 12.0% and diversity reduced to 42.4% (Figures. 4 and 5). *Corema*, the dominant of open heath is reduced from over 100 % cover to less than 2 % cover in stands of Scots Pine (Figure 5). Other than Scots Pine, invasive alien species were not prominent in the sites studied and they did not increase in the presence of Scots Pine (Tables 1 and 2).

After invasion by Scots Pine forest, *Deschampsia flexuosa* replaces *Corema conradii* as the dominant vascular plant and ground cover is greatly reduced (Tables 1 and 2). Significant species, including *Amelanchier lucida* Fernald, *Vaccinium angustifolium* Ait., and species of *Rubus*, all of which provide food for pollinators that service local crops (apples, blueberries, etc) are severely reduced after invasion by Scots Pine. These same species and several others are also potentially important as sources of genetic variation for crop improvement.

The numbers of immature Scots Pines in open heathland ranged from 80–350 per acre and were 99 % of the trees on open heath adjacent to the Scots Pine stands. Native pines and other trees apparently invade the drier

TABLE 1. Frequency of species less than 2 m high in three major associations, open heath, Red Pine heath and Scots Pine forest. The recording was done in 2003 in an area that was a natural heathland dominated by Corema with Red and White Pines 50 years earlier. Introduced species are indicated with an asterisk (*) following the species name.

Species	Open Heath		Red Pine Heath		Scots Pine	
	1	2	3	4	5	6
Acer rubrum L.	–	–	10	–	–	5
Amelanchier lucida Fern.	25	55	5	–	–	5
Amelanchier laevis Wieg.	–	5	5	–	–	–
Arctostaphylos uva–ursi (L.) Spreng.	20	15	10	25	–	–
Aronia melanocarpa (Michx.) Ell.	30	–	–	–	–	–
Betula populifolia Marshall	10	–	–	–	–	–
Carex tonsa (Fern.) Bickn. var. *rugosperma* (Mack.) Crins	15	–	5	–	–	–
Comptonia peregrina (L.) Coult.	15	20	5	5	–	–
Corema conradii Torr.	95	95	60	35	30	–
Cypripedium acaule Aiton	–	–	20	25	–	–
Danthonia spicata (L.) Beauv.	–	25	–	–	–	–
Deschampsia flexuosa (L.) Trin.	20	55	55	50	65	75
Dichanthelium acuminatum (Sw.) Gould & Clark ssp. *fasciculatum* (Torr.) Freckman & Lelong	5	–	–	–	–	–
Dichanthelium depauperatum (Muhl.) Gould	5	–	–	–	–	–
Festuca filiformis Pourret *	–	30	–	–	–	–
Gaultheria procumbens L.	5	5	–	–	–	5
Gaylussaccia baccata (Wang.) K. Koch	–	–	–	10	–	–
Hieracium pilosella L. *	–	–	5	–	–	10
Hudsonia ericoides L.	10	–	–	–	–	–
Hypericum perforatum L. *	5	–	–	–	–	–
Juniperus communis L.	5	–	–	–	–	5
Kalmia angustifolia L.	10	20	–	–	–	–
Maianthemum canadense Desf.	–	–	55	–	–	5
Melampyrum lineare Desr.	–	20	30	20	5	–
Monotropa hypopithys L.	–	–	–	–	5	–
Pinus resinosa Ait.	–	–	–	5	–	–
Pinus strobus L.	–	–	15	–	–	–
Pinus sylvestris L. *	15	15	–	–	5	–
Pteridium aquilinum (L.) Kuhn.	–	10	–	–	–	–
Quercus rubra L.	–	–	5	–	–	–
Rubus vermontanus Blanch.	5	5	–	–	–	–
Rumex acetosella L. *	10	–	–	–	–	–
Solidago bicolor L.	15	35	5	–	10	–
Solidago juncea Ait.	–	5	–	–	–	–
Trientalis borealis Raf.	–	–	35	–	–	5
Vaccinium angustifolium Ait.	50	70	90	80	20	10
Viburnum nudum L. var. *cassinoides* (L.) Torr. & Gray	–	5	–	–	–	–
Total native species	17	16	16	9	6	8
Total introduced species	3	2	1	0	1	1
Total species	20	18	17	9	7	9
Mean community frequency	16.5		12.5		7.0	
% of mean open heath frequency	100.0		75.7		42.4	

TABLE 2. Mean cover of species less than 2 m high in three major associations, open heath, Red Pine heath and Scots Pine forest. The recording was done in 2003 in an area that was a natural heathland dominated by Corema with Red and White Pines 50 years earlier. Introduced species are indicated with an asterisk (*) following the species name.

Species	Open Heath		Red Pine Heath		Scots Pine	
	1	2	3	4	5	6
Acer rubrum L.	–	–	0.10	–	–	0.45
Amelanchier lucida Fern.	4.80	13.55	0.05	–	–	0.50
Amelanchier laevis Wieg.	–	2.00	0.15	–	–	–
Arctostaphylos uva-ursi (L.) Spreng.	1.60	11.50	1.15	9.9	–	–
Aronia melanocarpa (Michx.) Ell.	3.55	–	–	–	–	–
Betula populifolia Marshall	2.35	–	–	–	–	–
Carex tonsa (Fern.) Bickn.var. *rugosperma* (Mack.) Crins	0.50	–	0.05	–	–	–
Comptonia peregrina (L.) Coult.	4.75	1.85	1.25	0.25	–	–
Corema conradii Torr.	105.00	110.25	13.65	6.10	1.50	–
Cypripedium acaule Aiton	–	–	0.35	0.60	–	–
Danthonia spicata (L.) Beauv.	–	0.25	–	–	–	–
Deschampsia flexuosa (L.) Trin.	0.50	1.50	11.10	14.10	17.65	13.40
Dichanthelium acuminatum (Sw.) Gould & Clark ssp. *fasciculatum* (Torr.) Freckman & Lelong	0.05	–	–	–	–	–
Dichanthelium depauperatum (Muhl.) Gould	0.05	–	–	–	–	–
Festuca filiformis Pourret *	–	0.30	–	–	–	–
Gaultheria procumbens L.	1.50	0.20	–	–	–	0.40
Gaylussaccia baccata (Wang.) K. Koch	–	–	–	2.85	–	–
Hieracium pilosella L. *	–	–	0.10	–	–	0.45
Hudsonia ericoides L.	0.75	–	–	–	–	–
Hypericum perforatum L. *	0.12	–	–	–	–	–
Juniperus communis L.	2.50	–	–	–	–	0.35
Kalmia angustifolia L.	5.90	2.95	–	–	–	–
Maianthemum canadense Desf.	–	–	11.80	–	–	0.35
Melampyrum lineare Desr.	–	0.80	0.35	5.95	1.00	–
Monotropa hypopithys L.	–	–	–	–	0.10	–
Pinus resinosa Ait.	–	–	–	0.05	–	–
Pinus strobus L.	–	–	0.35	–	–	–
Pinus sylvestris L. *	3.00	2.6	–	–	0.25	–
Pteridium aquilinum (L.) Kuhn.	–	2.9	–	–	–	–
Quercus rubra L.	–	–	0.05	–	–	
Rubus vermontanus Blanch.	0.24	0.60	–	–	–	–
Rumex acetosella L. *	3.20	–	–	–	–	–
Solidago bicolor L.	0.25	2.10	0.05	–	0.50	–
Solidago juncea Ait.	0.10	0.25	–	–	–	–
Trientalis borealis Raf.	–	–	0.95	–	–	0.05
Vaccinium angustifolium Ait.	5.65	31.45	29.5	43.95	2.50	0.45
Viburnum nudum L. var. *cassinoides* (L.) Torr. & Gray	–	0.10	–	–	–	–
Total for all species	146.26	185.15	71.05	83.75	23.50	16.40
Mean community cover		162.89		77.35		19.6
% of mean open heath cover		100.0		47.5		12.0

FIGURE 3. Open Red Pine stand northwest of Kingston (approximately 44.9916° N, 64.9750° W) with heath vegetation dominated by blueberry (*Vaccinium angustifolium*).

open heathland very slowly or not at all, whereas the European Scots Pine is an aggressive invader that forms dense stands. These not only reduce the biodiversity of native vascular plant species, but they also eliminate the native open heathland ecosystem. Management of Scots Pine will be necessary to protect representative sites.

The threat of Scots Pine to natural ecosystems is apparently best documented in New Zealand where "wilding" (escaped from cultivation) conifers have had a major impact on the natural landscape. Of these conifers, Scots Pine is rated among the species having the greatest impact on the natural ecosystem and substantial effort has been directed to control and management (e.g., Langer 1992).

In the United States, various agencies have recommended against the planting of Scots Pine due to its invasive tendency, but, as is the case for Canada, quantification of impact is very limited. The lack of detail is in direct contrast to the abundance of anecdotes. For example it has been noted that: "to appreciate the problem of invading alien trees and shrubs in Canada, one need only consider the planting of Scots Pine (*Pinus sylvestris*) in native open habitats that have become thoroughly choked with this aggressive weed tree" (Catling 1997). Scots Pine was featured as one of 16 invasive aliens of wetland habitats in Canada and one of 40 invasives of upland habitats in Canada (White et al. 1993). It has also been mentioned in the context of serious invasives in various provinces (e.g., Kaiser 1983; Riley 1989; Urban Forest Associates Inc. 2002). and environmental organizations have advised against its use as an ornamental.

The demonstrated impact on a portion of the declining Nova Scotian heathland ecosystem is significant as one of the first quantified examples of impact of invasive alien Scots Pine in North America. It should serve as a basis for monitoring impacts in Nova Scotia and elsewhere. Clearly the concerns that have been widely expressed by environmental organizations and field biologists for impact of invasive alien Scots Pines are justified.

In addition to reduction of Corema heathland due to succession and invasive Scots Pine, there has also been substantial reduction due to urban and agricultural development (Figure 1) and decline of this ecosystem has been rapid over the past few decades. The need to protect representative examples is well known. The

FIGURE 4. Scots Pine (*Pinus sylvestris*) of many different age classes invading open heathland dominated by Corema (*Corema conradii*) on the west side of Auburn (approximately 45.0083° N, 64.8916° W).

FIGURE 5 Dense stand of Scots Pine (*Pinus sylvestris*) with ground covered mostly by pine litter on the west side of Auburn (approximately 45.0166° N, 64.8833° W).

remnants of this ecosystem provide pollinators for adjacent fruit crops and contain distinctive variants of native crop relatives that could be valuable in crop improvement and diversification (see above and Catling et al. 2004). Thus they are sources of valuable biodiversity. The perpetuation of this important ecosystem will require not only a system of protected sites but also management of succession and invasive aliens, particularly Scots Pine.

Acknowledgments

Frances MacKinnon at Nova Scotia Department of Natural Resources assisted with access to air photos. Useful comments were provided by W. J. Cody and J. Cayouette. Field assistance was provided by S. P. Vander Kloet and S. Javorek.

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Received 1 April 2004
Accepted 18 April 2005

Insect Visitation to Wildflowers in the Endangered Garry Oak, *Quercus garryana,* Ecosystem of British Columbia

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Parachnowitsch, A. L., and E. Elle. 2005. Insect visitation to wildflowers in the endangered Garry Oak, *Quercus garryana,* Ecosystem of British Columbia. Canadian Field-Naturalist 119(2): 245-253.

The Garry Oak Ecosystem (GOE) is a fragmented and endangered ecosystem in Canada, and is currently the focus of conservation and restoration efforts in British Columbia. However, little is known about the basic biology of GOE forbs, or their relationships with pollinating insects. We monitored wildflowers and their insect visitors in 25 quadrats within a 25 × 25 metre plot, located in a fragment of the GOE near Duncan, British Columbia, for six weeks (the majority of the flowering period). Overall, 21 native and non-native forb species flowered in our quadrats during the survey, and we observed an additional six forb species flowering outside of our quadrats. Eight forbs were visited within quadrats by a total of 13 insect taxa, identified to morphospecies. Visits by eight additional morphospecies were observed outside of the quadrats. In general, visitation was low; however, most insect morphospecies were observed visiting more than one plant species, and most plant species were visited by more than one insect morphospecies, suggesting that pollination may be generalised in this community. A χ^2 analysis indicated that insect visitation was not proportional to the relative abundance of forbs, with higher than expected visitation to Common camas (*Camassia quamash*), and no observed visits to 11 species, most with very small (putatively unattractive) flowers. The most frequent insect visitor was the introduced Honeybee, *Apis mellifera*, followed by native mason bees (*Osmia* spp.) and mining bees (*Andrena* spp.). Our observations provide baseline data for future, detailed studies that should investigate the importance of plant-pollinator mutualisms for sustainability of populations and communities in this rare ecosystem.

Key Words: Garry Oak Ecosystem, *Quercus garryana* plant-pollinator interactions, Common Camas, *Camassia quamash*, British Columbia.

The Garry Oak Ecosystem (GOE), an open woodland habitat dominated by Garry Oak (*Quercus garryana*), is increasingly of conservation concern. The GOE ranges from California to British Columbia (Erickson 2000), and within British Columbia is restricted to dry, nutrient-poor sites within the Coastal Douglas-fir biogeoclimatic zone (Klinka et al. 1996). Since western settlement, the GOE has become highly fragmented, with as little as 1% of its original area still remaining (Fuchs 2001). There are currently 117 GOE plant and animal species listed as endangered, threatened or vulnerable by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and/or the British Columbia, Ministry of Sustainable Resource Management, and in Canada, the entire ecosystem is considered endangered (Garry Oak Recovery Team 2003*).

Historically, the GOE has been maintained by fire disturbance and large-scale aboriginal cultivation (harvesting, weeding, replanting and controlled burning) of *Camassia quamash* (Common Camas) bulbs (Thilenius 1968; Turner and Kuhnlein 1983; MacDougall et al. 2004). However, European settlers imposed fire suppression and livestock grazing, leading to the encroachment of conifers into the GOE, and also introduced several highly invasive species; e.g., *Cytisus scoparius* (Scotch Broom) and *Poa pratensis* (Kentucky Blue Grass; Thilenius 1968; MacDougall et al. 2004). Fire suppression, non-native species introductions, and conversion of land to agricultural or urban use have fragmented the GOE, and current research aims to understand the implications of this fragmentation for *Q. garryana* establishment (Fuchs et al. 2000; Regan and Agee 2004) and to manage invasive and native species (e.g., Ussery and Krannitz 1998; Tveten and Fonda 1999; MacDougall and Turkington 2004). However, little is known about the basic ecology of native herbaceous forb communities within the GOE beyond status reports of a few rare species (Douglas and Illingworth 1997, 1998; Douglas and Ryan 1998; Penny and Douglas 2001) and studies of the reproductive biology of *Aster curtus* (currently *Sericocarpus rigidus*; Clampitt 1987; Bigger 1999; Giblin and Hamilton 1999).

One area of special concern is the paucity of data on plant-pollinator interactions within the GOE (Fuchs 2001). Pollination can be central to recruitment and maintenance of individual species, and can thereby provide an essential ecosystem service (Kearns et al. 1998; Black et al. 2001). Habitat loss and fragmentation, agricultural practices such as herbicide and pesticide use, and the encroachment of non-native species can all negatively impact plant and pollinator populations, and may disrupt the interaction between them as well. For example, two recent reviews highlighted that increased fragmentation leads to an increased probability of pollinator failure and reduced plant reproductive success (Aizen et al. 2002; Wilcock and Neiland 2002). These effects can be exacerbated by increased inbreeding depression in small populations (e.g., Severns 2003; Kephart 2004). Even highly local

fragmentation can reduce pollinator visitation rates and seed production, and lead to greater expression of inbreeding depression within metapopulations (Lennartsson 2002).

Most of the aforementioned studies relating habitat loss to pollination issues focus on single plant species. It is essential, however, to first determine the relationships between interacting communities of plants and pollinators, so as to direct future research towards those interactions likely to be most important either for single-species conservation or for community-level restoration. An improved understanding of the reproductive ecology of native GOE forbs could lead to more effective management tactics. Thus, we investigated visitation patterns of potential insect pollinators to a forb community in a remnant of the GOE. Our goal was to determine the richness and abundance of visiting insect taxa and patterns of insect visitation to GOE forbs, in order to provide baseline data on plant-pollinator interactions within the GOE. Specifically we asked:

(1) What forbs are present and what insects visit them?

(2) How diverse are the insect visitors and do insect taxa visit only one plant species or many?

(3) How do forb abundance and insect visitation change throughout the season?

Methods

Field Site

The Cowichan Garry Oak Preserve near Duncan, British Columbia (48°48'30.8"N, 123°37'52.5"W) is a 12.3 ha remnant of the GOE which once encompassed as much as 45 000 ha throughout the Cowichan Valley. Within the private preserve (owned by the Nature Conservancy of Canada) there are a number of large, forb-dominated gaps in the woodland, one of which we chose for study. The Nature Conservancy of Canada actively manages the area, primarily through removal of *C. scoparius*.

Forb surveys

Prior to flowering in 2002, we laid out a 25 × 25 m plot which encompassed the majority of the woodland gap. Within each 5 × 5 m cell of the plot, a 0.5 m^2 rectangular sampling quadrat was randomly located, for a total of 25 quadrats. The number of flowering stems was counted for each forb within each quadrat in six, weekly surveys from 23 April until 30 May. This period encompassed the majority of the flowering season (see Results). Voucher specimens of all forbs were deposited in the Simon Fraser University Herbarium, Burnaby, British Columbia. Plant identification follows Douglas et al. (1998). For each of the forbs present, we also present estimates of flower size and flower number per inflorescence based on Douglas et al. (1998; Table 1) as floral traits are known to affect insect visitation patterns.

Floral visitor surveys

Several different methods can be used to assess the community of floral visitors, each with positive and negative attributes. Because we were interested in the interaction between plants and potential pollinators for the entire plant community, and wanted to impact the site as little as possible, we used a combination of direct observation and pan trapping for this research. Direct observation of visitors to flowers allows the best description of relationships between plants and potential pollinators, and so was our method of choice. Direct observation of visitation, however, does not usually allow complete identification of floral visitors "on the wing". Survey methods like pan trapping or sweep netting can increase the total insect "catch" and allow for accurate identification of captured specimens, but information gained has limited utility for community-level studies as these methods do not allow evaluation of interactions between plants and visitors and frequently capture insects that are not floral visitors. In addition, sweep netting can damage plants by breaking off flowering stems. Because we wanted to increase our number of captured insects for identification, we used pan traps as the less damaging capture method. Floral visitor surveys were performed from 23 April to 23 May, and then were terminated as there were few flowering stems remaining.

Direct observations

Each of the 25 quadrats was observed for two, 15-minute periods each week by two observers. Observations were made on sunny days between 09:00 and 17:00, and the order of quadrat observation was randomised for each of the two observers. A visit was counted if an insect was observed probing at least one flower on a plant. Insect taxa were identified based on morphological features visible in the field (morphospecies) and representative specimens of each morphospecies were collected between observation periods and identified as completely as possible in the lab. Because of low visitation rates and our desire to minimize our impact on pollinator populations, we collected only enough specimens to confirm morphospecies. In most cases morphospecies contain several taxonomic species, a limitation of the direct observation method, and so our identifications to genus will under-represent the taxonomic diversity of floral visitors. For example, *Osmia* sp. 1 are large-bodied *Osmia* (approximately 1 cm long) and include *O. lignaria*, *O. texana*, and possibly other species with similar appearance on the wing, but not captured for inclusion with our voucher specimens. Because visitation rates were generally low (see Results), visits to flowering stems outside the quadrats were also recorded. These casual observations may have been biased towards larger, more apparent insects, but are included in an effort to make visitation data as complete as possible.

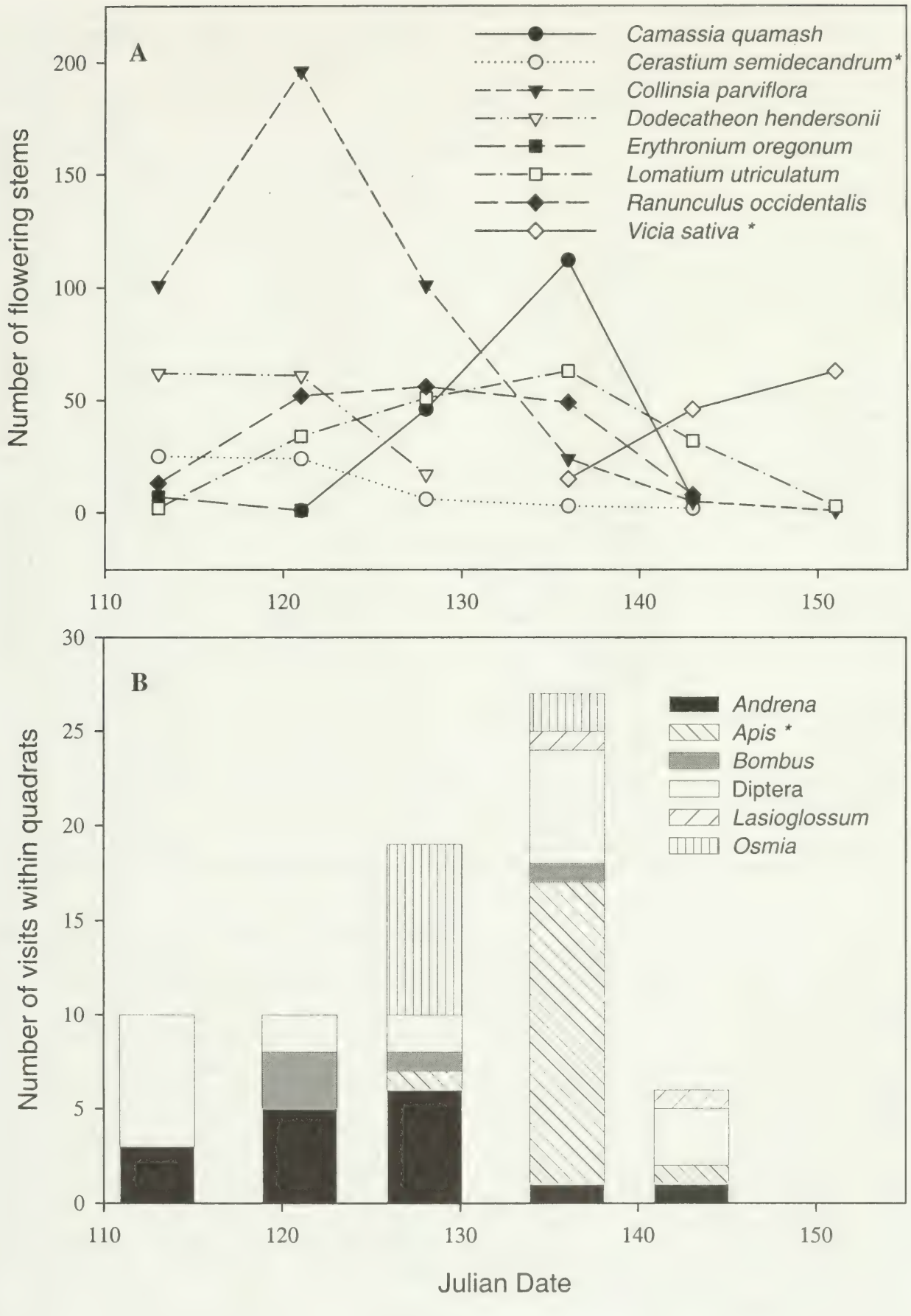

FIGURE 1: A. (top) Phenology and abundance of visited plant species (within quadrats) at the Cowichan Garry Oak Preserve. B. (bottom) Phenology of insect visitation within quadrats grouped by genus of visitors (family for Diptera). An asterisk (*) indicates non-native species origin. No observations of floral visitors were made during the last floral survey due to the large number of quadrats with few or no flowering stems.

TABLE 1. List of flowering plant species sampled in quadrats, followed by six other species that we observed flowering at the Cowichan Garry Oak Preserve but which were not present in quadrats. An asterisk (*) indicates non-native origin, and a dagger (†) indicates an endangered or threatened species. Peak flowering date includes the total number of flowering stems in all quadrats. Small, medium and large flower size estimates indicate flower diameters <1cm, 1-3 cm, and >3 cm, respectively. Flower number indicates plants that usually have few open flowers per stem (<10) or many (>10), unless indicated more precisely (Douglas et al. 1998).

Scientific name	Common name	Peak flowering date (# stems)	Flower size	Flower number
Cardamine sp.	Bitter-cress	23/04/02 (12)	small	few
Camassia quamash	Common Camas	16/05/02 (112)	large	5 +
Cerastium arvense	Field Chickweed	31/05/02 (6)	medium	few
*Cerastium semidecandrum**	Little Mouse-ear	23/04/02 (25)	small	few
Claytonia perfoliata	Miner's-lettuce	01/05/02 (13)	small	few
Collinsia parviflora	Blue-eyed Mary	01/05/02 (196)	small	1 – many
*Cytisus scoparius**	Scotch Broom	23/05/02 (3)	medium	many
Dodecatheon hendersonii	Broad-leaved Shootingstar	23/04/02 (62)	medium	2 – 15
Erythronium oregonum	White Fawn Lily	23/04/02 (7)	large	usually 1
Galium aparine	Cleavers	16/05/02 (600)	small	many
*Geranium molle**	Dovefoot Geranium	23/05/02 (15)	medium	2 – many
*Lathyrus sphaericus**	Grass Peavine	23/05/02 (37)	medium	few
Lithophragma parviflorum	Small-flowered Woodland Star	01/05/02 (1)	medium	5 – 11
Lomatium utriculatum	Spring Gold	16/05/02 (63)	small	many
Montia linearis	Narrow-leaved Montia	23/04/02 (4)	small	many
*Myosotis discolor**	Common Forget-me-not	31/05/02 (4)	small	many
Phlox gracilis	Slender Phlox	16/05/02 (14)	small	many
Ranunculus occidentalis	Western Buttercup	08/05/02 (56)	medium	few
Sanicula crassicaulis	Pacific Sanicle	23/05/02 (3)	small	many
*Valerianella locusta**	Corn Salad	16/05/02 (758)	small	many
*Vicia sativa**	Common Vetch	31/05/02 (63)	medium	few
Also flowering at the site:				
Achillea millefolium	Yarrow		small	many
Fritillaria affinis	Chocolate Lily		large	1 – 5
Sericocarpus rigidus†	White-top Aster		small	many
Triteleia grandiflora var. *howellii*†	Howell's Brodiaea		medium	many
Viola praemorsa ssp. *praemorsa*†	Yellow Montane Violet		medium	few
Zygadenus venenosus	Meadow Death-camas		medium	many

Pan trapping

A set of three pan traps (yellow, white, and blue to reduce colour bias: Leong and Thorp 1999) was placed at a random point along each of the five north-south transects making up the 25 × 25 m^2 grid (i.e., five sets). Pans were filled with ca. 250 mL of water and a few drops of glycerol (Kearns and Inouye 1993) and set out on each observation date for at least 6 hours. Captured insects were preserved in ethanol prior to identification. Identification of Hymenoptera, Lepidoptera and Diptera followed Michener et al. (1994), Guppy and Shepard (2001) and McAlpine et al. (1981), respectively. Voucher specimens of all morphospecies were deposited with the Simon Fraser University Natural History Museum.

Statistical analyses

To illustrate the overall patterns of visitation, we present a matrix of the interactions between forbs and putative pollinator morphospecies (Table 1) and calculate the sum of interaction types for both the forb species and insect morphospecies. For each sampling date, we used a χ^2 analysis to test whether the number of visits to each plant species (summed across quadrats) was proportional to the number of available stems of each species. All plant species that were flowering within quadrats on a particular date were included in these analyses. To test whether visitation patterns were determined by the phenology of the forbs (i.e., that later-flowering species had more visits), we performed a regression of the total number of visits a plant species received (pooled over all dates and quadrats) on peak species flowering date (1) including all species, and (2) including only the eight forbs that received visits, to avoid bias due to the many zero values for unvisited species.

Results

Twenty-one forb species were observed flowering within quadrats, 14 native and 7 non-native (Table 1). Most of the species had small (11 species) or medium (8 species) flower size while only *Camassia quamash* and *Erythronium oregonum* had large flowers (greater than 3 cm diameter); 10 of the species generally pro-

TABLE 2. Visits by 21 insect morphospecies, grouped by family, to 11 plant species at the Cowichan Garry Oak Preserve. A (+) indicates at least one observed visit within or outside quadrats, an asterisk (*) indicates non-native origin, and a dagger (†) indicates a species "at risk". Totals indicate the number of forb species an insect morphospecies was observed to visit and vice versa.

Plant Species Floral Visitors	*Camassia quamash*	*Cerastium arvense*	*Cerastium semidecandrum**	*Collinsia parviflora*	*Dodecatheon hendersonii*	*Erythronium oregonum*	*Fritillaria affinis*	*Lomatium utriculatum*	*Ranunculus occidentalis*	*Valerianella locusta**	*Vicia sativa**	Totals
Hymenoptera												
ANDRENIDAE												
Andrena sp. 1	+			+								2
Andrena sp. 2	+	+		+		+			+	+		6
Andrena sp. 3	+	+		+				+	+			5
APIDAE												
*Apis mellifera**	+								+			2
Bombus bifarius	+			+	+	+						4
Bombus flavifrons	+				+						+	3
HALICTIDAE												
Halictus sp.	+	+		+					+			4
Lassioglossum sp.	+							+	+		+	4
MEGACHILIDAE												
Osmia sp. 1	+								+			2
Osmia sp. 2	+											1
Osmia sp. (male)	+											1
Diptera												
BOMBYLIIDAE												
Bombylius major	+				+			+	+			4
Unidentified sp.								+				1
SYRPHIDAE												
Merodon equestris	+	+						+				3
Volucella bombylans	+											1
Other Syrphidae	+		+				+	+	+			5
Lepidoptera												
HESPERIDAE												
Erynnis propertius†	+										+	2
LYCAENIDAE												
Celastrina echo	+											1
NYMPHALIDAE												
Phyciodes mylitta								+				1
PAPILIONIDAE												
Papilio sp.					+							1
PIERIDAE												
*Pieris rapae**	+											1
Totals	18	4	1	5	4	2	1	7	8	1	3	54

duce fewer than 10 flowers per flowering stem (Table 1). Only 10 of the forb species had a density greater than 2 flowering stems/m^2 in our quadrats on their peak flowering date (Table 1). Our sampling period captured the peak spring flowering period of 13 of these species (Table 1, Figure 1A); five species had a peak flowering date before the start of the survey (or on 23 April), including *Cardamine* sp., *Cerastium semidecandrum*, *Dodecatheon hendersonii*, *Erythronium oregonum* and *Montia linearis* while only *Cerastium arvense*, *Myosotis discolor*, and *Vicia sativa* continued to increase in abundance after the survey. Six additional native forb species were present at the site, including three species at risk, but were not present in our sampling quadrats due to low frequency or patchy distribution (Table 1).

Visitation frequency was low (0.5-3.9 visits/hr). Flower visitors were observed on 11 forb species (Table 2) but on only 8 of the 21 forbs available within the quadrats (Table 3). On four of the five sampling dates the number of visits to each forb species was different from that expected based on the number of flowering stems available (23 April : χ^2 =28.7, df = 8, P = 0.0004; 1 May: χ^2 = 12.8, df = 13, P = 0.4666; 8 May: χ^2 = 101.7, df = 11, P < 0.0001; 16 May: χ^2 = 312.7, df = 15, P < 0.0001; 23 May: χ^2 = 182.1, df = 16, P < 0.0001).

Thirteen insect morphospecies were observed visiting forbs flowering within quadrats, and eight additional morphospecies were observed visiting forbs at the site (Table 4). Hymenoptera accounted for the largest percentage of visits within quadrats (71.4%) with the remaining visits by Diptera. *Osmia* sp. 1 were large-bodied mason bees, *Osmia* sp. 2 were small-bodied mason bees; *Andrena* morphospecies were distinguished based on relative size, abdominal markings, and dense hairs on the thorax. "Other Syrphidae" refers to the common, striped hoverflies such as species of *Syrphus* and *Metasyrphus* which could not be distinguished on the wing. The majority of observed visits were made by *Apis mellifera* (honeybee), followed by the native *Osmia* and *Andrena* spp. (Table 4). Within quadrats, *A. mellifera* was observed visiting *C. quamash* exclusively, and 88.9% of observed *A. mellifera* visits occurred during the date of peak *C. quamash* bloom. Most floral visitors did not exhibit this fidelity, however; 13 of the 21 morphospecies observed visited more than one forb species, and eight of the 11 visited forb species were visited by more than one insect morphospecies (Table 2). As the season progressed, more visits from a greater number of insect morphospecies were observed until most of the forbs had senesced (Figure 1B). Although there were more visits observed later in the season, there was no relationship between peak flowering date and the number of visits received by a plant species (R^2 = 0.0002, $F_{1,19}$ = 0.00, P = 0.96), even when only the eight visited forbs were considered (R^2 = 0.079, $F_{1,7}$ = 0.52, P = 0.50).

TABLE 3. Number of floral visits observed within quadrats by insect morphospecies. Visits are summed across quadrats, the eight visited plant species and surveys from 23 April to 23 May 2002.

Floral visitors	# Visits	% of Visits
Hymenoptera		
Andrena sp. 1	1	1.4
Andrena sp. 2	9	12.9
Andrena sp. 3	4	5.7
Apis mellifera	18	25.7
Bombus bifarius	4	5.7
Bombus flavifrons	1	1.4
Lassioglossum sp.	2	2.9
Osmia sp. 1	10	14.3
Osmia sp. (male)	1	1.4
Diptera		
Bombylius major	6	8.6
Unidentified bombyliid sp.	3	4.3
Volucella bombylans	2	2.9
Other Syrphidae	9	12.9

TABLE 4. Distribution of observed visits (all insect species combined) among the 8 plant species that received visits within quadrats. Data derived by pooling across all quadrats and observation periods (23 April to 23 May, 2002). An asterisk (*) indicates non-native origin.

Plant species	# Visits	% of Visits
Camassia quamash	37	52.9
*Cerastium semidecandrum**	1	1.4
Collinsia parviflora	8	11.4
Dodecatheon hendersonii	5	7.1
Erythronium oregonum	1	1.4
Lomatium utriculatum	7	10.0
Ranunculus occidentalis	10	14.3
*Vicia sativa**	1	1.4

Pan traps caught only nine individuals throughout the sampling period, including four *Andrena* (species 2, 3 and one additional morphospecies not seen during the observation periods), one *Osmia* male (a different morphospecies than the male *Osmia* seen during the observation period), one *Volucella bombylans*, two of the unidentified Bombyliid observed visiting flowers, and a male *Megachile* sp. that was not observed visiting flowers. Low catches precluded further analysis.

Discussion

Visitation rates within this fragment of the GOE were low in 2002 (maximum rate 3.9 visits/hr of observation, on 16 May), but eight of 11 forb species that received visits were visited by more than one insect morphospecies and 13 of the 21 insect morphospecies were observed visiting more than one plant species (Table 2). Because of the low number of visitors observed, it is difficult to make inferences about the

degree of specialisation of individual insect morphospecies; however, most visited forbs appear to have generalised insect visitation patterns. Similarly generalised visitation patterns were observed at the same site in 2001, although visitation rates were higher (Elle and Carney 2003). In that survey, conducted over a shorter time (equivalent to our third and fourth census dates) and so not inclusive of the flowering period of many GOE forbs, visitation by 14 insect morphospecies to just four forb species (all visited by multiple morphospecies) was observed at a rate of 28.5 visits/hr. Among-year variation in visitation rate is not uncommon in spring-flowering communities (e.g., Motten 1986; Burd 1994), but it is unknown whether the unpredictability of visitation limits reproductive success of GOE forbs.

The number of observed visits to each forb species differed from that expected based on flowering stem availability on all but one sampling date, suggesting some degree of preference on the part of insect visitors. *Camassia quamash* was visited by the most diverse group of insects (16 of the 21 observed morphospecies) and received the majority of visits (52.9 %). On its peak flowering date (16 May), *C. quamash* was common (flowering in 22 of 25 quadrats), and received 24 of the 26 observed visits. This forb produces large flowers on multi-flowered inflorescences (Table 1), and may have high nectar rewards. In contrast, the majority of forbs within our quadrats with no observed visits (9 of 11) have small and/or few flowers (Table 1), and may be less attractive to insect foragers; several are likely self-fertilised (i.e., *Galium aparine*, *Montia linearis*, *Myosotis discolor*). Although low visitation rates temper our conclusion of non-random visitation, similarly non-random visitation was observed at this site the year before the current study (Elle and Carney 2003).

The composition of the flowering forb community and the insects that visited them changed over the duration of our study (Figure 1). It is possible that the phenological differences in forb abundance influenced visitation. For instance, *C. quamash* was the most abundant plant on 16 May, which coincided with the greatest number of observed visits, in particular by *Apis mellifera*, which visited *C. quamash* almost exclusively (Figure 1B). However, the results of the regressions of number of insect visits on peak flowering date suggest that flowering later does not lead to increased total visitation; we suggest instead that *C. quamash* is simply highly attractive to insects.

The high abundance and diversity of visitors to *C. quamash* (at least relative to other plants) suggests that it may have an important ecological role in this community; it may serve as a "magnet" species for pollinators and enhance pollination of neighbouring species by increasing the overall size and/or diversity of the pollinator community (Thomson 1978; Laverty 1992). The only pollinator species that were present but not observed visiting *C. quamash* included rarely observed species (two Lepidoptera; Table 2) and possibly a specialist fly (the unidentified Bombyliid was observed numerous times outside the quadrats but only visiting *Lomatium utriculatum*). Our study did not address interactions of *C. quamash* with other plants in the community; however, the relatively high frequency and variety of visitors to *C. quamash* suggests that future research could test whether this species has competitive or facilitative effects on forb pollination within the GOE.

Bees were the most common floral visitors in our study and are major pollinators globally (Kearns and Inouye 1997). Early in the sampling period, *Osmia* and *Andrena* spp. were frequently observed (Figure 1B), although the most frequently observed visitor overall was *Apis mellifera* (honeybee), which has been introduced world wide from Europe and is used for crop pollination (Kearns and Inouye 1997). *Apis mellifera* has been implicated in the decline of native pollinators (Kearns et al. 1998 and references therein; Goulson 2003; Thomson 2004) and so its potential impacts on plant-pollinator relationships in the GOE need to be considered. Our study did not address interactions between *A. mellifera* and other bees. However, *A. mellifera* visited *C. quamash* almost exclusively both in the present study and a previous study at this site (Elle and Carney 2003), and thus the potential for negative effects on other pollinators will depend on the importance of *C. quamash* as a nectar or pollen resource for native pollinators (which generally visited other plants in addition to *C. quamash*, Table 2). Our data do suggest that if native pollinators were to decline for reasons other than competition with honeybees (e.g., loss of appropriate nesting habitat), *A. mellifera* would not provide pollination services for plant species other than *C. quamash*.

Our study provides initial data on plant-pollinator interactions in the GOE, but additional, detailed study is necessary to determine the importance of plant-pollinator mutualisms for the sustainability of the community as a whole. Further research is needed to determine the effectiveness and importance of insect visitors for pollination of GOE forbs, and whether these insects are at risk due to habitat or nesting requirements. The numerous forb species for which we've never observed any visits, at both the Cowichan Garry Oak Preserve and other sites (Elle and Carney 2003) should be investigated to determine if they are, indeed, reproducing maximally via autogamy, or if they are instead pollen limited. Our data suggest that pollination of visited plant species may be generalized, however, and so this ecosystem may be resilient to the loss of individual pollinating insect species (Waser et al. 1996). More research is important to determine whether rare GOE forbs are at risk due to failed mutualisms (e.g., Bond 1994).

Acknowledgments

The authors thank T. Ennis and the Nature Conservancy of Canada for access to the Cowichan Garry Oak Preserve. J. Biernaskie, S. Campbell, C. Caruso, B.

Husband, M. Schuetz and two anonymous reviewers provided constructive feedback on earlier versions of the manuscript, and J. Biernaskie, M. Schuetz, and M. Thane provided field assistance. Funding was provided through an Undergraduate Student Research Award to A.L.P. and an operating grant to E.E., both from the Natural Sciences and Engineering Research Council of Canada.

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Received 18 October 2002
Accepted 5 April 2005

An Annotated Checklist of the Spiders of Newfoundland

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Pickavance, J. R., and C. D. Dondale. 2005. An annotated checklist of the spiders of Newfoundland. Canadian Field-Naturalist 119(2): 254-275.

Since Hackman's report in 1954 of 216 (adjusted from a total of 220 for apparent errors) spider species from Newfoundland, the total has grown by 68% to 363. An annotated checklist is presented. Of this total, 223 (c. 61%) are Nearctic, 119 (c. 33%) are Holarctic and 21 (c. 6%) are introduced. Comparisons are made with other Canadian spider faunas. The introduced species and the proportions of Linyphiidae, Lycosidae and Dictynidae are discussed.

Key Words: Araneae, species distribution, introduced species, Newfoundland.

Hackman's (1954) list of Newfoundland (referring solely to the insular portion of the province of that name) spiders was the first such report for any Canadian province. Since then lists for four more provinces and territories have been published: British Columbia (West et al. 1984, 1988; Bennett 2001); Yukon (Dondale et al. 1997); Manitoba (Aitchison-Benell and Dondale 1990), and Quebec (Bélanger and Hutchinson 1992; Paquin et al. 2001, Paquin and Dupérré 2003). We have made use of additional unpublished data for Alberta and Saskatchewan (Buckle and Holmberg 2004*) and British Columbia (Bennett et al. 2004*).

In 2002 the formal, political name of the province formerly called Newfoundland was changed by Act of Federal Parliament to Newfoundland and Labrador. Therefore since that date it has been proper to use Newfoundland to refer solely to the insular part of the province, and that is the practice adopted here. Newfoundland was entirely or almost entirely covered by ice in the most recent (Wisconsin) glaciation, which reached its maximum extent probably around 24 000 years BP (Dyke et al. 2002). The ice then underwent a series of retreats until the coastal margins of Newfoundland were exposed around 12 000 BP (Shaw 2003), after which time the ice continued to retreat and leave the land exposed. The modern fauna was presumably established by post-glacial immigration aided by some anthropogenic introductions. The presence or absence of biological refugia during that glaciation has long been debated. Such refugia could have been important contributors to the post-glacial colonisation, and evidence thought to indicate their existence in Newfoundland has been presented from a variety of taxa (e.g., Fernald 1924; Wynne-Edwards 1937; Belland 1987; Hamilton and Langor 1987). Ballooning from continental North America on the region's prevailing westerly winds probably accounted for the post-glacial arrival of most of Newfoundland's spider species.

It is not altogether clear which species were brought to Newfoundland by humans. The introduction of Palaearctic species by humans is relatively straightforward. The first documented European visitors were Vikings, briefly established at L'Anse aux Meadows around 1000 BP (Wallace 1991). Then since the late 15th century European settlement and commercial traffic can explain the presence of Palaearctic species in Newfoundland. In addition, some Nearctic and Holarctic species may have been brought to the island by the traffic between Newfoundland and the maritime provinces, Labrador and the eastern seaboard of the United States. There were also approximately 5 000 years of aboriginal occupation of Newfoundland before the arrival of Europeans, with continual aboriginal traffic between Labrador and Newfoundland (Renouf 1999). This may account for the presence of some Holarctic and subarctic-Nearctic species.

By whatever means of arrival, 363 species are now known from Newfoundland, an increase of 68% over Hackman's (1954) report of 216 (adjusted total) species.

Ecology of Newfoundland

Newfoundland lies in the northwest Atlantic between approximately 47°-52° north and 53°-59° west and lies within the general ecological region of the Boreal Shield Ecozone. Eleven Ecoregions (encompassing 25 Ecodistricts) are distinguished in Newfoundland, and full details of these are in Ecological Stratification Working Group (1995). More general biogeographical information can be found in South (1983).

Newfoundland's climate is influenced by the surrounding Atlantic ocean in general and the cold Labrador current to the east in particular. Climate varies between the Ecoregions, from a low subarctic ecoclimate in the Strait of Belle Isle Ecoregion on the Northern Peninsula (mean annual temperature 2.5°C), through the maritime high boreal ecoclimate of the Long Range

Mountains (mean annual temperature 4°C), the maritime mid-boreal ecoclimate of Central Newfoundland (mean annual temperature 4.5°C), to the oceanic low boreal ecoclimate of the South Avalon-Burin Oceanic Barrens (mean annual temperature 5.5°C). The dominant vegetation is a mixture of Black Spruce (*Picea mariana*), White Spruce (*Picea glauca*), Balsam Fir (*Abies balsamia*), Tamarack (*Larix decidua*), lesser amounts of birch (*Betula*), extensive peatlands, communities of ericaceous shrubs, crowberry (*Empetrum*) barrens, and mosses and lichens. At higher elevations areas of semi-exposed bedrock are frequent.

Materials and Methods

Abbreviations

Throughout the text the following abbreviations may be employed: AB = Alberta; AMNH = American Museum of Natural History; BC = British Columbia; BL = Belcher Islands, Hudson Bay; CDD = C. D. Dondale; CNC = Canadian National Collection of Insects and Arachnids, Agriculture and Agri-Food Canada, Ottawa; GL = Greenland; GMNP = Gros Morne National Park, Newfoundland; FMNH = Finnish Museum of Natural History, Helsinki; HZ = Hazen Camp, Ellesmere Island; JRP = J. R. Pickavance; MB = Manitoba; MCZ = Museum of Comparative Zoology, Harvard; NF = Island of Newfoundland; PL = Peary Land, Greenland; QC = Quebec; SK = Saskatchewan; TNNP = Terra Nova National Park, NF; YK = Yukon.

A note on Hackman's species total

We have reduced Hackman's (1954) total of 220 by four to give a revised total of 216. Hackman (1954) listed some species on the basis of immature specimens, some of which have not subsequently been confirmed. CDD examined the supposed juveniles of *Tetragnatha caudata* Emerton and *T. vermiformis* Emerton and concluded that the specimens are of uncertain identity. These two species have therefore been removed from Hackman's (1954) total. Hackman (1954) recorded three species of *Dolomedes* from Newfoundland: *D. fulviatronotatus* Bishop, *D. scapularis* C. L. Koch and *D. vittatus* Walckenaer. *Dolomedes fulviatronotatus* is now *D. striatus* Giebel, and his *D. vittatus* was a misidentified specimen of *D. striatus*. In addition, his record of *D. scapularis* (junior synonym of *D. triton* (Walckenaer)) cannot be confirmed because this species is not in Hackman's collection in FMNH, has not subsequently been found in Newfoundland, and has never been brought in by the public for identification (unlike virtually all other species with large adults). We have therefore removed two of the three *Dolomedes* from Hackman's (1954) total.

This paper is based on published reports of Newfoundland spiders, specimens in the CNC, examination by CDD of collections of Newfoundland spiders deposited elsewhere, and extensive collections by JRP over the last 14 years. Apart from the major collections reported by Hackman (1954), reports of Newfoundland spiders are rare. These consist of accounts of scattered, small collections (e.g., Pickard-Cambridge 1881; Emerton 1914, 1915, 1927) or lists assembled for particular purposes, e.g., Lindroth's (1957) comparison of European and North American faunas. A number of collectors (e.g., Lloyd Hollett and Kevin Pardy) have deposited Newfoundland specimens in the CNC but have not formally reported on their collections. Most records of Newfoundland spiders occur in taxonomic works such as Gertsch and Ivie (1955), Ivie (1969), Leech (1972), Dondale and Redner (1978, 1982, 1990), Platnick and Dondale (1992), Buckle and Roney (1995), Saaristo and Koponen (1998), and Miller (1999).

We have followed Platnick (2005) for familial placement for the sake of uniformity and consistency. We have followed Platnick (2005) for genera and species names, except that we follow Buckle et al. (2001) for linyphiid nomenclature. For convenience families and species are in alphabetical order.

Species recorded by Hackman (1954) are indicated "[H]". Included in such brackets is the name he used if different from the name in Platnick (2005*) and other relevant notes.

The designations of Nearctic, Holarctic, or Palaearctic listed for each species have been gleaned from various sources (e.g., Buckle et al. 2001; Dondale and Redner 1978, 1982, 1990; Dondale et al. 2003; Platnick 2005*; Roberts 1993). Here we use these terms to mean the biogeographical origin of a species rather than the present-day distribution. For example, *Araneus diadematus* Clerck is listed as Holarctic by Platnick (2005*), but is originally a Palaearctic species introduced to North America (Dondale et al. 2003). Therefore we refer to this and similar species as "Palaearctic; introduced".

It has sometimes been difficult to decide whether a species should be called Palaearctic introduced or truly Holarctic. For example, Buckle et al. (2001) describe *Erigone dentipalpis* (Wider *in* Reuss) as "Introduced?" while Platnick (2005*) lists it as Holarctic. Pending clarification we treat this and similar cases as introduced Palaearctic species. Spider introductions to North America were also dealt with by Lindroth (1957), but because significant portions of his information about spiders has been superceded by later work we have placed less emphasis on his records. A particularly problematic species is *Theridiosoma gemmosum* (L. Koch), traditionally regarded as Palaearctic introduced to North America (e.g., Locket and Millidge 1953). Coddington (1986) questioned this and pointed out it might be a Nearctic species introduced to Europe because it is common in North America but rare in Europe. Here we follow the traditional position because the species is confined to the eastern part of North America, where it may be common because of the amount of its preferred habitat of old-growth and (to a lesser extent) second-growth forest (Coddington 1986), whereas it is very widespread in Europe and Asia.

The true distribution and habitat preferences of most Newfoundland spider species are unknown, with some species known only from one or two records. Note that the localities in the list below more often reflect the activities of collectors than the true distribution of the species. Only a general habitat description is given for each species unless there is some obvious correlation with a particular environment. Note that the term "mixed coniferous woods" (which occurs regularly in the checklist) encompasses a wide diversity of micro-habitats such as dry litter, wet litter, patches of wetland, moss, lichens, bark, leaves, standing water, running water, patches of hardwood shrubs and patches of herbs as well as boundaries with more extensive areas of wetland, barrens or rocky areas. Additional habitat information has been taken from Bélanger and Hutchinson (1992) because the majority of Newfoundland species occur in Quebec, which at least in the middle of that province is broadly ecologically similar to Newfoundland. Habitat information has also been gathered from a variety of other sources, e.g., Chamberlin and Gertsch (1958); Dondale and Redner (1978, 1982, 1990); Dondale et al. (2003); Levi (1971); Opell and Beatty (1976); Paquin and Dupérré (2003) and Platnick and Dondale (1992).

Dates, Depositories and Localities

Dates are expressed e.g. 5Aug98; an unknown day and/or month indicated by 00 (but 00 in the year position means 2000); specimens from a range of dates are indicated e.g. 12-28Aug98. If no date is given collection date is uncertain. One specimen is indicated ♂ or ♀; more than one specimen ♂♂ or ♀♀. Records from other collectors are not included except where no records exist in the JRP collection. All specimens are in the JRP collection (Biology Department, Memorial University of Newfoundland) unless otherwise noted; specimens held elsewhere are indicated e.g. (CNC); specimens of species held both in JRP collection and elsewhere are indicated e.g. (and CNC). For each species a maximum of five locations is given; if a species is known from more than five locations, five were selected to show the general distribution. Locations are arranged alphabetically. Place names are in accordance with Natural Resources Canada: Canadian Geographical Names (2005*) where additional data such as latitude and longitude can be found.

Checklist of Newfoundland Spiders

AGELENIDAE (4 spp.)

Agelenopsis utahana (Chamberlin & Ivie, 1933) [H]
Nearctic. Among herbaceous plants in clearings in coniferous woods; corners of walls and fences. Norris Point 18Aug 02♂; Port au Choix 12Jul99♂.

Tegenaria atrica C. L. Koch, 1843
Palaearctic; introduced. Warehouses in Donovans Industrial Park, St. John's.
St. John's 00May95♀.

Tegenaria domestica (Clerck, 1758)
Palaearctic; introduced. This synanthropic species is common across Newfoundland inside houses (particularly basements), sheds and other structures.
Norris Point14Aug97♂; Port au Choix 9Jul04♂; Portugal Cove 27May89♂; St. John's 29Sep97♀; TNNP 11Jun93♂.

Tegenaria duellica Simon, 1875
Palaearctic; introduced. Buildings in the Waterford Bridge valley, St. John's.
St. John's 1Jun01♀; St. John's 20Sep04♂♂.

AMAUROBIIDAE (5 spp.)

Amaurobius borealis Emerton, 1909 [H; *Walmus borealis* (Emerton)]
Nearctic. Litter of mixed coniferous woods.
Berry Head Pond (GMNP) 10Jul00♀; Gander 00Aug98♂; Glide Lake 00Jul96♀; Main River west 29Jul00♂.

Callobius bennetti (Blackwall, 1846) [H]
Nearctic. Litter of mixed coniferous woods; among stones at the back of beaches.
Bakers Brook estuary 11Aug99♀; Green Point 26Aug98♀; Port au Choix 5Jul04♀; Sugar Loaf (St. John's) 00Oct92♀; TNNP 11Jun93♂.

Coras montanus (Emerton, 1890) [H; Agelenidae]
Nearctic. Litter of mixed coniferous woods; under bark; in crevices between rocks.
Harbour Grace 27May94♀; St. John's 00Jan96♀; St. John's 00Sep97♂.

Cybaeopsis euopla (Bishop & Crosby, 1935) [H; *Callioplus euoplus* Bishop & Crosby]
Nearctic. Litter of mixed coniferous woods.
Berry Head Pond (GMNP) 19Jul00♂; Glide Lake 00Jul96♂♂; Main River west 00Jul98♂♂; Nameless Cove 16Aug01♀♀; Port au Choix 8Jul00♂.

Cybaeopsis tibialis (Emerton, 1888) [H; *Callioplus tibialis* (Emerton)]
Nearctic. Litter of mixed coniferous woods.
Main River west 6Jun98 ♀♂.

ARANEIDAE (20 spp.)

Aculepeira carbonarioides (Keyserling, 1892)
Holarctic. In NF, known only from higher elevations of the Long Range Mountains. It spins large webs strung between boulders and is often seen at the centre of the web during daylight.
Gros Morne Mountain 14Aug94♀; Highlands of St. John 1Aug98♀; Killdevil Mountain 9Aug93♀; Tablelands 12Jun94♀♀; Winter House Brook canyon 31Jul97♀♀♂.

Araneus corticarius (Emerton, 1884) [H; from a juvenile female that is not *A. corticarius*]
Nearctic. Mixed coniferous woods; among bog and swamp-loving trees and shrubs.
Main River west 12Aug00♂.

Araneus diadematus Clerck, 1758 [H]
Palaearctic; introduced. This is the common Garden Spider of western Europe, often called the Cross Spider in North America because of the characteristic dorsum pattern. Widespread in NF, particularly abundant around human settlements and associated gardens. Also found away from human habitations, although this often indicates an abandoned community (see the discussion of this species below).
Lewisporte 00Oct92♀; Mortier Bay 00Oct92♀; Norris Point 18Aug99♂♂; Paradise 00Aug93♀; St. John's 8Sep98♀.

Araneus groenlandicola (Strand, 1906)
Nearctic. On herbs, low shrubs and stunted trees on open or barren land near the coast. In NF known only from coastal Northern Peninsula; it may be confined to that colder, subarctic area.
Bakers Brook estuary 27Aug98♀; Burnt Cape 4Aug98♀; Point Riche 15Aug97♀; Port au Choix 20Aug02♀♀; Shallow Bay 9Aug98♀♀.

Araneus marmoreus Clerck, 1758
Holarctic. Mixed coniferous woods; low shrubs near such woods; on rock-cuts along roads through such woods.
Mount Scio 00Aug95♂; Norris Point 30 Jul97♀; Rocky Harbour (Millbrook) 8Aug97♀; Woody Point (Lookout Hills) 11Aug97♀.

Araneus nordmanni (Thorell, 1870)
Holarctic. Mixed coniferous woods; wooden fences and breakwaters.
Boutitou 17Jul03♀; Ferryland 21Sep98♀.

Araneus saevus (L. Koch, 1872) [H; *Araneus solitarius* (Emerton 1884)]
Holarctic. Mixed coniferous woods; garden vegetation.
Topsail (St. John's) 15Aug96♂.

Araneus trifolium (Hentz, 1847) [H]
Nearctic. Low shrubs on open or barren ground; tall herbs in clearings in coniferous woods.
Burgeo 13Aug03♀; Lobster Cove 20Aug99♀; Logy Bay 20Aug03♀; Norris Point 15Jul99♂; Rocky Harbour (Bottom Brook bog) 16Jul99♂.

Araneus washingtoni Levi, 1971
Nearctic. Mixed coniferous woods; low bushes.
Eddies Cove West 30Jul49♀ (MCZ?); Gambo 25Apr49♀ (MCZ?).

Araniella displicata (Hentz, 1847) [H; *Araneus displicatus* (Hentz)]
Holarctic. Mixed coniferous woods. Common.
Bakers Brook estuary 12Aug97♀; Gander 00Jul98♂♂; Logy Bay 13 Aug 01♀; Millertown 26Jun80♀♂; St. John's 8Sep98♀♀.

Araniella proxima (Kulczyński, 1885)
Holarctic. Mixed coniferous woods. In NF known only from the west of the island.
St Lunaire 15Aug00♂.

Cyclosa conica (Pallas, 1772) [H]
Holarctic. Mixed coniferous woods. Common.
Blackhead (St. John's) 26Jun97♂; Boutitou 17Jul03♀; Gander 20Jul98♂♂; St. John's 13Sep98♀♀; Stuckless Pond 20Jul93♀♀.

Hypsosinga pygmaea (Sundevall, 1831) [H; *Singa variabilis* Emerton 1884]
Holarctic. Edges of mixed coniferous woods; shrubs and herbs in peatlands.
Bay d'Espoir 11Jul85♀ (CNC); Bottom Brook (which one unknown) 19Aug86♀ (CNC); North Arm Mountain (Bonne Bay) 13Aug81♀♀ (CNC).

Hypsosinga rubens (Hentz, 1847)
Nearctic. Mixed coniferous woods; shrubs and herbs in peatlands.
Gander 00Jun-00Jul81♂ (CNC); Hinds Point 29Jun87♀ (CNC).

Larinioides cornutus (Clerck, 1758)
Holarctic. Shrubs; low trees; between boulders on the Long Range Mountains (where it can co-occur with *Aculepeira carbonarioides*). Common.
Big Brook 18Jun02♀♀; New Ferolle 13Jul04♀♂; Quidi Vidi 19Sep98♀♀; Tablelands 31Jul97♀♀; Table Point 16Aug99♀♀.

Larinioides patagiatus (Clerck, 1758)
Holarctic. Mixed coniferous woods; low cliffs; tall herbs and shrubs; stunted trees; houses, outbuildings; lower elevations of mountain slopes. Common at least in the centre and west.
Badger 24Jun80♂; Big Brook 25Jun02♀; Boutitou 17Jul03♂; Norris Point 30 Jul97♀; Point Riche 15Aug97♀♂.

Larinioides sclopetarius (Clerck, 1758)
Palaearctic; introduced. On houses, sheds and outbuildings, fences, bridges; on mixed vegetation near such structures. Common.
Deer Lake 12Sep98 ♀; Epworth 2Jun01♂; Norris Point 5Aug99♂; Rocky Harbour 9Aug97♀; St. John's 4Nov93♂.

Metepeira palustris Chamberlin & Ivie, 1942 [H]
Nearctic. Clearings and fallen timber in mixed coniferous woods.
Gander 28Jul98♂.

Zygiella atrica (C. L. Koch, 1845)
Palaearctic; introduced. Among rocks near the coast; on breakwaters and other coastal structures; fences and buildings. Common around the greater St. John's area and the Avalon Peninsula in general; also in Deer lake. Elsewhere around the coast only *Z. nearctica* is found.
Deer Lake 12Sep97♀♀; Ferryland 21Sep98♀♂; Flatrock 2Nov 97♀♂; Logy Bay 16Sep03♀♂; Quidi Vidi 12Oct97♀♀♂.

Zygiella nearctica Gertsch, 1964 [H; *Zygiella montana* (C. L. Koch, 1834)]
Nearctic. Mixed coniferous woods; shrubs; low sea-cliffs; boulders, wharves and other structures near the ocean.
Conche 16Jul03♀♂; Lomond 18Jul97♂; Port au Choix 1Aug97♀♀♂; Table Point 5Aug97♀♂; TNNP 11Jun93♂.

CLUBIONIDAE (14 spp.)
Clubiona abbotii L. Koch, 1866 [H]
Nearctic. Litter of mixed coniferous woods; litter under shrubs; edges of peatlands.
Bakers Brook estuary 8-27Aug00♂.

Clubiona bryantae Gertsch, 1941 [H]
Nearctic. Litter of mixed coniferous woods and shrubs; rocks at back of beaches; litter at edge of sand dunes; bogs.
Berry Head Pond (GMNP) 19Jul00♂; Blackhead (St. John's) 12Nov02♀♀♂; Green Point 6Jul97♂; Nameless Cove 16Aug01♀♀; Shallow Bay 14Aug98♀.

Clubiona canadensis Emerton, 1890 [H]
Nearctic. Mixed coniferous woods; among herbs in clearings in woods; under bark; on sedges and herbs in wetlands; in leaf-litter in gardens and cultivated areas. Common.
Bakers Brook 8-27Aug00♀♂; Hawkes Bay 1Jul99♀; Port au Choix 20Jul99♀♂; Squid Cove road 19Jul98♀♂; St. John's 2Apr00♀;

Clubiona furcata Emerton, 1919 [H]
Holarctic. Mixed coniferous woods; litter under shrubs and herbs in marshy places.
Main River west 00Jul98♀.

Clubiona johnsoni Gertsch, 1941
Nearctic. Mixed coniferous woods.
TNNP 15Aug80♂ (CNC).

Clubiona kastoni Gertsch, 1941
Nearctic. Mixed coniferous woods.
Port au Choix 3-11Aug00♀♂.

Clubiona kulczynskii Lessert, 1905 [H]
Holarctic. Mixed coniferous woods; herbs in clearings in woods; *Empetrum* barrens.
Cape Raven 15Aug99♀; Gander 00Aug98♀♂; Main River west 00Jul98♀♂; Port au Choix 13Jul99♀.

Clubiona mixta Emerton, 1890 [H]
Nearctic. Shrubs and herbs.
Twillingate Island 8Jul51♀ (FMNH).

Clubiona moesta Banks, 1896
Holarctic. Mixed coniferous woods.
Pasadena 14Aug84♂ (CNC).

Clubiona norvegica Strand, 1900 [H]
Holarctic. Back of beaches; sand dunes; barren, rocky areas near the coast. Common in the west.
Big Brook 14Jul01♀♀♂; Conche 27Jul04♀; New Ferolle 18Aug00♀♀♂♂; Savage Cove 30Jun03♀♀♂; St Pauls 25Jul97♀♂.

Clubiona obesa Hentz, 1847 [H]
Nearctic. Shrubs and herbs.
Deer Lake 30May51♀ (FMNH); Spruce Brook (Georges Lake) 8Jul49♀ (FMNH).

Clubiona opeongo Edwards, 1958
Nearctic. Exposed rocky barrens.
Eddies Cove East 21Jun00♂.

Clubiona riparia L. Koch, 1866 [H]
Holarctic. Mixed coniferous woods; herbs in clearings in woods; vegetation at back of beaches.
Bakers Brook estuary 26Aug98♀; Green Gardens 5Jul97♂; Norris Point 20Jun00♂; Stanford River 28Jul99♀.

Clubiona trivialis C. L. Koch, 1843
Holarctic. Mixed coniferous woods; herbs in clearings in woods; mixed vegetation at back of beaches.
Blackhead (St. John's) 16Oct01♀; Burnt Cape 4Aug98♂; Gander 00Aug98♀♂; Lobster Cove 23Jul97♂♂; Norris Point 27Jun00♀.

CYBAEIDAE (1 sp.)
Cybaeota calcarata (Emerton, 1911)
Nearctic. Litter of mixed coniferous woods.
Norris Point 22Jul00♀♀.

DICTYNIDAE (9 spp.)
Argenna obesa Emerton, 1911 [H]
Nearctic. Wetlands; river banks; clearings in woods.
Come by Chance♀ (CNC); Grand Bank 3Aug51♀♀ (FMNH).

Dictyna alaskae Chamberlin & Ivie, 1947
Holarctic. Mixed coniferous woods; shrubs and herbs.
Hampden 18-20Jun77♀♀♂♂ (CNC).

Dictyna arundinacea (Linnaeus, 1758)
Holarctic. Mixed coniferous woods; shrubs and herbs.
Bay d'Espoir 11Jul85♀♂♂ (CNC); Hampden 12Jul77♀ (CNC); TNNP 7Jul87♀ (CNC).

Dictyna bostoniensis Emerton, 1888 [H]
Nearctic. Mixed coniferous woods; shrubs and herbs.
Joe Glodes Pond 21Aug49♀♂ (FMNH); Pasadena ♀ (CNC); St. John's 21Jul86♀ (CNC).

Dictyna brevitarsus Emerton, 1915 [H]
Nearctic. Mixed coniferous woods; shrubs and herbs.
Stag Brook (GMNP)17Jul99♀♂.

Dictyna minuta Emerton, 1888
Nearctic. Mixed coniferous woods.
Berry Head Pond (GMNP) 18Jul99♀; Gadds Harbour 27Jul97♂ (CNC); Norris Point 27Jul98♀ (and CNC).

Emblyna annulipes (Blackwall, 1846) [H; *Dictyna annulipes* Blackwall]
Holarctic. Mixed coniferous woods.
Grandy Brook 2Jun49♀ (FMNH); Hampden 5- 29Jun86♀♀♂ (CNC); Pasadena 14Jun84♀ (CNC); Portland Creek 00Jun74♂ (CNC).

Emblyna phylax (Gertsch & Ivie, 1936) [H; *Dictyna phylax* Gertsch & Ivie]
Nearctic. Mixed coniferous woods.
Gander 00Jul98♂.

Iviella sp.
Not attributed to species; probably new; to be described elsewhere.
Nearctic. Only known from exposed sub-arctic *Empetrum* barrens on the Northern Peninsula.
Burnt Cape 00Aug03♀♂♂; Killdevil Mountain 17Aug99♀♂; Point Riche 17Aug98♀♀♂♂; Table Point 30Sep98♂.

GNAPHOSIDAE (14 spp.)
Drassodes neglectus (Keyserling, 1887) [H]
Holarctic. Under stones on talus slopes; rocky barren areas; among stones at the back of beaches.
Conche 16Jul03♀♀; Burnt Cape 00Jul03♀♀♂♂; Killdevil Mountain 8Aug94♂; Point Riche 17Jul00♀♂; Port au Choix 4Jul03♂.

Gnaphosa brumalis Thorell, 1875
Nearctic. Wetlands; *Empetrum* barrens near coast.
Burnt Cape 00Aug03♂; Port au Choix 2Aug96♀; Woody Point (Lookout Hills) 5Jun97♀.

Gnaphosa microps Holm, 1939
Holarctic. Wetlands; *Empetrum* barrens.
Big Brook 21Jun02♀; Killdevil Mountain 17Aug99♀♀♂♂; Point Riche 1Aug99♂; Sally's Cove 27Jul99♀; St Lunaire 00Aug00♀.

Gnaphosa muscorum (L. Koch, 1866) [H]
Holarctic. *Empetrum* barrens; rocky areas.
Burnt Cape 00Aug03♀♀♂♂.

Gnaphosa parvula Banks, 1896 [H]
Nearctic. *Empetrum* barrens; rocky areas.
Cape Ray 1Jul96♀.

Haplodrassus hiemalis (Emerton, 1909) [H]
Holarctic. *Empetrum* barrens; rocky areas; peatlands.
New Ferolle 13Jul04♀; Point Riche 2Aug99♀♀; Table Point 30Sep98♀♀.

Haplodrassus signifer (C. L. Koch, 1839) [H]
Holarctic. Litter of shrubs and mixed coniferous woods.
Burnt Cape 00Aug03♂♂.

Micaria aenea Thorell, 1871
Holarctic. Litter of shrubs and mixed coniferous woods; peatlands.
Main River west 00Jul98♂.

Micaria constricta Emerton, 1894 [H; *M. longispina* Emerton, 1911]
Holarctic. *Empetrum* barrens; rocky areas; peatlands; mixed coniferous woods.
Base of Killdevil Mountain 13Jul49♀ (FMNH).

Micaria pulicaria (Sundevall, 1831) [H]
Holarctic. *Empetrum* barrens; rocky areas; peatlands; mixed coniferous woods.
Gadds Harbour 11Aug99♂; Point Riche 20Aug02♂; Shallow Bay 14Aug97♀; Tablelands 18Aug99♀; Western Brook estuary 24Aug03♀♂.

Micaria rossica Thorell, 1875
Holarctic. Exposed sub-arctic *Empetrum* barrens on the Northern Peninsula.
Burnt Cape 00Aug03♀.

Orodrassus canadensis Platnick & Shadab, 1975 [H; *O. vastus* Chamberlin & Ivie, 1922]
Nearctic. Mixed coniferous woods.
Doctors Brook 31Jul49♀ (FMNH); Eddies Cove West 2Aug49♀♀♂ (FMNH).

Zelotes fratris Chamberlin, 1920 [H; *Z. subterraneus* (C. L. Koch, 1833)]
Holarctic. Sand-dunes; rocky coastal areas; shrubby areas on lower slopes of mountains; abandoned meadows. Common.
Badger 24Jun80♀; Conche 27Jul04♀; St. John's 00Jun95♀♀♂♂; Tablelands 18Aug99♀♀♂♂; Western Brook estuary 25Jul97♀♀♂♂.

Zelotes sula Lowrie and Gertsch, 1955
Holarctic. Edge of peatlands; coastal *Empetrum* barrens.
Burnt Cape 00Aug03♀♀♂♂; Point Riche 19Aug00♀♂♂.

HAHNIIDAE (6 spp.)
Antistea brunnea (Emerton, 1909) [H]
Nearctic. Peatlands; wet parts of mixed coniferous woods.
Bakers Brook estuary 9Aug99♂; Berry Head Pond (GMNP) 31Jul00♂; Main River west 00Jul98♀♀; Rocky Harbour 23Jul-20Aug99♀♀.

Cryphoeca montana Emerton, 1909 [H; Agelenidae]
Nearctic. Mixed coniferous woods; under bark; shrubby areas at lower elevations of mountains.
Berry Head Pond (GMNP) 18Jul99♀; Gander 00Aug 98♂♂; Port au Choix 28Jun99♂; Tablelands 21Jul99♂; TNNP 11Jun93♀.

Hahnia cinerea Emerton, 1890 [H]
Nearctic. Peatlands and bogs.
Burnt Cape 00Aug03♀♀♂♂; Rocky Harbour 2Jul98♂.

Hahnia glacialis Sørensen, 1898
Holarctic. Coastal and alpine *Empetrum* barrens; mixed coniferous woods.
Big Brook 16Jul01♀♀♂; Conche 16Jul03♀; Nameless Cove 16Aug01♀♀♂♂; Point Riche 15Jul00♀♀; Savage Cove 14Jul01♀♀♂♂.

Neoantistea agilis (Keyserling, 1887) [H]
Nearctic. Lower slopes of mountains under rocks; litter under shrubs.
Tablelands 18Aug99♂♂.

Neoantistea magna (Keyserling, 1887) [H; *N. riparia radula* (Emerton, 1890)]
Nearctic. Mixed coniferous woods; coastal and alpine *Empetrum* barrens; back of beaches; peatlands and bogs.
Bakers Brook estuary 26Aug98♂; Big Brook 25Jun02♀♀; Hawkes Bay 9Jul04♂; base of Killdevil Mountain 17Aug99♀♂; Sally's Cove 10Aug99♀♂.

LINYPHIIDAE (191 spp.)
Note: we follow Buckle et al. (2001) for linyphiid nomenclature.

Agyneta allosubtilis Loksa, 1965 [H; *Argyneta decora* (O. Pickard-Cambridge, 1871)]
Holarctic. Mixed coniferous woods; shrubby areas.
Burnt Cape 00Aug03♀♀♂♂; Killdevil Mountain 20Jul00♂♂.

Agyneta amersaxatilis Saaristo & Koponen, 1998
Nearctic. Exposed coastal *Empetrum* barrens; rocky areas on exposed coasts.
Point Riche 24Jul00♂♂ (and CNC); Port au Choix 5Jul04♂.

Agyneta dynica Saaristo & Koponen, 1998 [H; *"Meioneta* sp. pr *rurestris*"; this may be *A. dynica]*
Nearctic. Exposed coastal and alpine *Empetrum* barrens; mixed coniferous woods.
Cape Raven 15Aug99♂; Point Riche 24Jul00♀♂.

Agyneta fabra (Keyserling, 1886)
Nearctic. Mixed coniferous woods.
Gander 00Aug98♂; Corner Brook 10Aug94♀.

Agyneta jacksoni (Braendegaard, 1937)
Nearctic. Mixed coniferous woods.
Lewis Hills 21Aug86♀ (CNC).

Agyneta olivacea (Emerton, 1882) [H; *Argyneta cauta* (O. P.-Cambridge, 1902)]
Holarctic. Mixed coniferous woods. Common.
Burnt Cape 00Aug03♀♀♂♂; Gander 1Jul78♀; Glide Lake 00Jul94♀♂; Savage Cove 14Jul01♂; TNNP 10Jun93♀♀♂.

Agyneta simplex (Emerton, 1926)
Nearctic. Exposed coastal *Empetrum* barrens.
New Ferolle 13Jul04♂; Point Riche 19Aug00♀♀; Burnt Cape 00Aug03♀♀♂♂.

Agyneta sp.
Not attributed to species (similar to CNC #6)
Mixed coniferous woods.
Main River west 00Jul98♂; Bakers Brook estuary 3Jul98♀.

Allomengea dentisetis (Grube, 1861) [H; *Helophora ontariensis* (Emerton, 1925)]
Holarctic. Exposed coastal *Empetrum* barrens.
New Ferolle 18Aug00♀♀♂; Sally's Cove 22Aug00♀♂; St. Lunaire 15Aug00♀.

Aphileta misera (O. Pickard-Cambridge, 1882) [H; *Eulaira concava* Chamberlin & Ivie, 1945]
Holarctic. Moist coniferous litter; coastal *Empetrum* barrens.
Brunette Island ♂ (CNC?).

Baryphyma kulczynskii (Eskov, 1979)
Holarctic. Mixed coniferous woods.
Pasadena 28May86♀, 16May88♀♂♂ (CNC).

Bathyphantes brevipes (Emerton, 1917) [H]
Nearctic. Mixed coniferous woods; stunted coniferous stands near coast; shrubs in road cuttings.
Big Brook 19Jun02♀♀♂♂; Nameless Cove 16Aug01♀♂; Point Riche 1Aug99♂; Port au Choix 13 Jul99♂; Rocky Harbour 30Jul97♂.

Bathyphantes brevis (Emerton, 1911) [H]
Nearctic. Litter around pools on *Empetrum* barrens.
Badger 22-25Jun51♀ (FMNH); Cow Head 8Aug49♀ (FMNH);

Deer Lake 30May51♀ (FMNH); South Branch (Codroy) 4Jul49♀ (FMNH).

Bathyphantes canadensis (Emerton, 1882)
Holarctic. Mixed coniferous woods.
Georges Lake 13Sep88♂ (CNC); Pasadena 28May86♀ (CNC); Steady Brook 11Jun84♀ (CNC).

Bathyphantes concolor (Wider *in* Reuss, 1834) [H]
Holarctic. Mixed coniferous woods; thickets of alder and other shrubs; coastal *Empetrum* barrens; back of beaches; gardens and cultivated areas. Common.
Bakers Brook estuary 8-27Aug00♀♂; Mount Scio 00Aug95♂; Port au Choix 1Aug99♂♂; Stanford River 29Jul99♂; St. John's 2Apr00♀♂.

Bathyphantes gracilis (Blackwall, 1841) [H]
Holarctic. Peatlands and bogs.
Berry Head Pond (GMNP) 19-31Jul00♀♀♂♂; Burnt Cape 00Aug03♀♀♂♂.

Bathyphantes pallidus (Banks, 1892) [H; *Bathyphantes* sp. probably *reprobus* (Kulczyński, 1916)]
Nearctic. Mixed coniferous woods; coastal *Empetrum* barrens.
Bakers Brook estuary 8-27Aug00♀♀♂♂; Burnt Cape 00Aug03♂; base of Killdevil Mountain 13Aug00♀♀♂♂.

Bathyphantes reprobus (Kulczyński, 1916).
Marusik et al. (1993) synonymised *B. crosbyi* (Emerton, 1919) under *B. reprobus*. CDD thinks the species are distinct and that Newfoundland specimens are *B. crosbyi*; see Buckle et al. 2001.
Holarctic. Mixed coniferous woods.
Main River west 00Jul98♂.

Bathyphantes simillimus (L. Koch, 1879)
Holarctic. Mixed coniferous woods.
Berry Head Pond (GMNP) 31Jul-15Aug00♀; Glide Lake 00Jul94♀; Main River west 00Jul98♀♂; Stanford River 29Jul99♂.

Carorita limnaea (Crosby & Bishop, 1927)
Holarctic. Peatlands; mosses in mixed coniferous woods.
Main River west 23Jul00♂.

Centromerita bicolor (Blackwall, 1833) [H; *Centromerus bicolor* (Blackwall)]
Palaearctic; introduced. Mixed coniferous woods; coastal *Empetrum* barrens.
Blackhead (St. John's) 7Oct-12Nov♀♀♂♂.

Centromerus cornupalpis (O. Pickard-Cambridge, 1875) [H]
Nearctic. Mixed coniferous woods.
Grand Bruit 13Jun49♀ (FMNH).

Centromerus denticulatus (Emerton, 1909)
Nearctic. Mixed coniferous woods; sphagnum bogs.
Rocky Harbour (Bottom Brook bog) 6Aug98♀.

Centromerus furcatus (Emerton, 1882)
Nearctic. Mixed coniferous woods.
Berry Head Pond (GMNP) 26Jul-14Aug00♂♂; Cook's Pond 4-10Jul94♂; Glide Lake 00Jul94♀; Port au Choix 13Jul99♂♂.

Centromerus latidens (Emerton, 1882) [H]
Nearctic. Mixed coniferous woods.
Burgeo, Cow Head, Gambo, Grand Bruit, Millertown: 11-20Jun49♀; 1-31Jul49 ♀♀; 1-31Aug49♀♀ (FMNH?). Dates not connected to localities; year assumed 1949 from context (Hackman 1954). Not found by CDD in Hackman's collections in FMNH. This record may be erroneous but is retained here pending clarification.

Centromerus longibulbus (Emerton, 1882) [H]
Nearctic. Mixed coniferous woods; sphagnum bogs.
Berry Head Pond (GMNP) 31Jul-15Aug00♀; Main River west 00Jul98♂; Port au Choix 8Jul00♂; TNNP 10Jun93♂.

Centromerus persolutus (O. Pickard-Cambridge, 1875) [H]
Nearctic. Mixed coniferous woods.
Corner Brook 10Aug94♀; Glide Lake 00Jul94♂.

Centromerus sylvaticus (Blackwall, 1841) [H] Holarctic. Mixed coniferous woods.
Cow Head 10Aug49♀ (FMNH?); Grandy Brook 24Jun49♀ (FMNH?). Not found by CDD in Hackman's collections in FMNH. This record may be erroneous but is retained here pending clarification.

Ceraticelus alticeps (Fox, 1891)
Nearctic. Mixed coniferous woods.
Corner Brook 17Aug84♀ (CNC).

Ceraticelus atriceps (O. Pickard-Cambridge, 1874) [H]
Nearctic. Mixed coniferous woods. Common.
Bakers Brook estuary 15Jul99♀; Big Brook 24Jun02♀♀; Burnt Cape 4Aug98♂; Norris Point 28Jul98♀♂; Port au Choix 12Jul99♀.

Ceraticelus bulbosus (Emerton, 1882)
Holarctic. Mixed coniferous woods.
Bay d'Espoir 11Jul85♀ (CNC); Brunette Island 18May85♀ (CNC); Eddies Cove (East or West not specified) 11Aug76♀ (CNC); Portland Creek 8Sep85♀♀ (CNC).

Ceraticelus fissiceps (O. Pickard-Cambridge, 1874) [H]
Nearctic. Mixed coniferous woods. Common.
Burnt Cape 00Aug03♀♂; Cow Head 7Aug97♀; Gander 28Jul98♂; Port au Choix 12 Jul99♂; Stanford River 28Jul99♂.

Ceraticelus laetabilis (O. Pickard-Cambridge, 1874) [H]
Nearctic. Mixed coniferous woods.
Glide Lake 00Jul94♂.

Ceraticelus laetus (O. Pickard-Cambridge, 1874)
Nearctic. Sphagnum bogs; mixed coniferous woods.
Rocky Harbour (Bottom Brook bog) 20Aug99♂.

Ceraticelus minutus (Emerton, 1882)
Nearctic. Mixed coniferous woods.
Gambo Pond 29Oct85♀ (CNC); Highlands River 14Aug84♀ ♀♂ (CNC); New Bay Pond 14Aug84♀ (CNC); Pasadena 19Jul84♂ (CNC); Triton Brook 29Oct85♀♂ (CNC).

Ceraticelus similis (Banks, 1892) [H]
Nearctic. *Empetrum* barrens; mixed coniferous woods.
Shallow Bay 9Aug98♂.

Ceratinella brunnea Emerton, 1882 [H]
Nearctic. Mixed coniferous woods; *Empetrum* barrens; sphagnum bogs. Common.
Big Brook 16Jul01♀; Blackhead (St. John's) 21Apr99♀; Burnt Cape 00Aug03♀♂; Norris Point 22Jul00♂; Port au Choix 1Aug99♀.

Ceratinella ornatula (Crosby & Bishop, 1925)
Nearctic. Mixed coniferous woods.
Hampden 29Jun77♀ (CNC).

Ceratinella parvula (Fox, 1891)
Nearctic. Mixed coniferous woods; rocky barrens.
Eddies Cove East 21Jun00♀; Main River west 00Jul98♂.

Ceratinops annulipes (Banks, 1892)
Nearctic. Sphagnum bogs.
Rocky Harbour (Bottom Brook bog) 13Aug98♀.

Ceratinopsis nigriceps Emerton, 1882
Nearctic. Mixed coniferous woods.
Badger 30Jul57♀ (CNC); Gander 14Jul78♂ (CNC).

Ceratinopsis nigripalpis Emerton, 1882
Nearctic. Mixed coniferous woods.
Gallows Cove 2Nov97♀.

Cheniseo sphagnicultor Bishop & Crosby, 1935
Nearctic. Sphagnum bogs.
Rocky Harbour (Bottom Brook bog) 13Aug99♀.

Dicymbium elongatum (Emerton, 1882)
Nearctic. Mixed coniferous woods.
Main River west 24Jul00♂.

Dicymbium nigrum (Blackwall, 1834)
Palaearctic; introduced. Mixed coniferous woods; shrubs in abandoned meadows; shrubs and trees in gardens. These are the only known North American records.
Gallows Cove 2Nov97♀♂ (and CNC); St. John's (Forest Avenue) 18Apr99♂; St. John's (University) 26Sep99♀.

Dietrichia hesperia Crosby & Bishop, 1933 [H]
Nearctic. Mixed coniferous woods.
Stephenville 29Oct47♂ (AMNH?). This record is based on a single male collected by Robert Traub and lent to Hackman by Dr. W. J. Gertsch. Hackman (1954) discussed whether the Newfoundland specimen was conspecific with a paratype (pages 17, 18) and put a question mark by this species in his checklist (page 6). It is assumed that Hackman returned the specimen to the AMNH. This record may be erroneous but is retained here pending clarification.

Diplocentria bidentata (Emerton, 1882) [H]
Holarctic. Mixed coniferous woods; shrubs; sphagnum bogs; *Empetrum* barrens; abandoned meadows; gardens. Common.
Berry Head Pond (GMNP) 4Aug99♂; Big Brook 19Jun02♀; Lobster Cove 22Jul99♂; Norris Point 28Jul98♀; Point Riche 1Aug99♂.

Diplocentria rectangulata (Emerton, 1915)
Holarctic. Mixed coniferous woods.
Main River west 00Jul98♂.

Diplocephalus cristatus (Blackwall, 1833) [H]
Holarctic. Mixed coniferous woods.
Port au Choix 13Jul99♂.

Diplocephalus subrostratus (O. Pickard-Cambridge, 1873) [H; *Diplocephalus cuneatus* (Emerton, 1909)]
Holarctic. Mixed coniferous woods.
Lloyds River 19Jun84♀♀♂ (CNC); Millertown 20Aug84♀♂ (CNC); Pasadena 23May88♀♀ (CNC); Point Leamington 24Sep84♀ (CNC).

Dismodicus alticeps Chamberlin & Ivie, 1947 [H]
Holarctic. Mixed coniferous woods.
Noel Paul's Brook 8Jul77♀ (CNC).

Dismodicus decemoculatus (Emerton, 1882) [H; *Dismodicus bifrons decemoculatus* (Emerton)]
Nearctic. Coastal *Empetrum* barrens; litter and rocks at back of beaches.
Big Brook 22Jun02♀♀♂♂; Port au Choix 5Jul04♂; Sally's Cove 21Jul00♀; St. Lunaire 15Aug00♀♂; Watts Point 29Jul98♀.

Drapetisca alteranda Chamberlin, 1909
Nearctic. Mixed coniferous woods.
St. John's 000022♀ (CNC).

Entelecara sombra (Chamberlin & Ivie, 1947)
Holarctic. *Empetrum* barrens at higher elevations and on tops of mountains; rocky coastal barrens in exposed places.
Big Brook 25Jun02♀♀; Conche 27Jul04♀; Highlands of St. John 14Aug00♀; Killdevil Mountain 26Jul99♀♂; Point Riche 24Jul00♀♂.

Eperigone bryantae Ivie & Barrows, 1935
Nearctic. Mixed coniferous woods.
Renews 28Jul72♀ (CNC).

Eperigone entomologica (Emerton, 1911)
Nearctic. Sphagnum bogs; mixed coniferous woods.
Bakers Brook estuary 14Jul98♀; Rocky Harbour (Bottom Brook bog) 12Aug98♀♂; Main River west 00Jul98♂.

Eperigone index (Emerton, 1914)
Nearctic. Sphagnum bogs; mixed coniferous woods.
Fermeuse 17Oct85♀ (CNC).

Eperigone maculata (Banks, 1892) [H]
Holarctic. Mixed coniferous woods.
Gander 17Jul78♂♂; Little Grand Lake 27Jul94♂.

Eperigone trilobata (Emerton, 1882) [H]
Holarctic. Coastal *Empetrum* barrens; mixed coniferous woods.
Blackhead (St. John's) 16Oct01♂.

Eperigone undulata (Emerton, 1914) [H; *Eperigone contorta* (Emerton, 1882)]
Nearctic. Coastal *Empetrum* barrens; mixed coniferous woods.
Bakers Brook estuary 9Aug99♂; Main River west 00Jul98♂.

Eridantes utibilis Crosby and Bishop, 1933 [H; *Scylaceus obtusus* Emerton, 1915]
Nearctic. Mixed coniferous woods.
Corner Brook 25Jul92♀; Squid Cove road 19Jul98♀; Port au Choix 24Jun00♀.

Erigone aletris (Crosby & Bishop, 1928) [H; *Erigone ephala* Crosby & Bishop, 1928]
Holarctic. Mixed coniferous woods; sphagnum bogs; litter, stones and low herbs at back of beaches; *Empetrum* barrens.
Bakers Brook estuary 13Sep97♀; Cape Freels 12Jul01♀♀; New Ferolle 10Aug00♀♀♂♂; Savage Cove 30Jun03♀♂; Seal Cove (Bonne Bay) 14Jul98♂.

Erigone atra Blackwall, 1833 [H]
Holarctic. Mixed coniferous woods.
Pasadena 28May86♂♂ (CNC).

Erigone blaesa Crosby & Bishop, 1928 [H]
Nearctic. Litter at back of beaches; litter around lakes; sand dunes.
Brunette Island 14Jul94♀; Cape Freels 12 Jul01♀♀♂♂; Western Brook Pond♀♀.

Erigone dentigera (O.Pickard-Cambridge, 1874) [H]
Holarctic. Mixed coniferous woods; abandoned meadows; sphagnum bogs.
Big Brook 24Jun02♂; Gadds Harbour 28Jul99♂; Main River west 29Jul00♂.

Erigone dentipalpis (Wider *in* Reuss, 1834)
Palaearctic; introduced. Coastal *Empetrum* barrens; mixed coniferous woods; gardens.
Blackhead (St. John's) 25Jul03♂; Main River west 25Jul00♂♂; St. John's 4Oct02♂.

Erigone ephala Crosby & Bishop, 1928 [H]
Nearctic. Mixed coniferous woods; back of beaches.
Berry Hill (GMNP) 29Jul76♂ (CNC); Brunette Island 7-8May86♀ (CNC); Chance Cove 25Jun85♀♀♂♂ (CNC); Eastport 7Aug76♂ (CNC); Stephenville 30Mar87♂ (CNC). Buckle et al. (2001) say "probably = *E. aletris*". Retained here pending clarification.

Erigone mentasta Chamberlin and Ivie, 1947 [H; female *Hilaira mentasta* (Chamberlin and Ivie); male a misidentification of *Sciastes dubius* (Hackman, 1954)]
Nearctic. Mixed coniferous woods.
Lomond 14Jul49♀ (FMNH).

Erigone whymperi O. Pickard-Cambridge, 1877 [H]
Nearctic. Mixed coniferous woods; *Empetrum* barrens.
Cooks Harbour 16Jul49♀ (FMNH); Doctors Hill (= Highlands of St. John, Port au Choix, not Doctor's Hill, Port Blandford) 29Jun49♀ (FMNH); Flowers Cove 25Jul49♀ (FMNH); Hare Bay 14Jul49♀ (FMNH); Waterford Bridge 5Jun49♀ (FMNH). These records of an essentially arctic species (Buckle et al. 2001) seem surprising. Hackman (1954, pages 18, 58) adds a question mark to his identification. Retained here pending clarification.

Estrandia grandaeva (Keyserling, 1886) [H]
Holarctic. Mixed coniferous woods.
Berry Head Pond (GMNP) 24Jul99♂; Lomond 12Aug93♀; Port au Choix 12Jul99♂♂; Shallow Bay 13Jul97♀♀(and CNC); Western Brook Pond 5Jul99♀♀ (and CNC).

Eulaira microtarsus (Emerton, 1882) [H]
Nearctic. Mixed coniferous woods.
Corner Brook 24Jul92♀; Glide Lake 00Jul94♀♀♂; Main River west 00Jul98♀♂.

Floricomus rostratus (Emerton, 1882)
Nearctic. Mixed coniferous woods.
Main River west 00Jul98♂.

Glyphesis scopulifer (Emerton, 1882) [H; *Tapinocyba scopuliferum* (Emerton)]
Nearctic. Mixed coniferous woods; edges of waterways.
Cow Head 8Jul49♀ (FMNH).

Gnathonaroides pedalis (Emerton, 1923)
Nearctic. Mixed coniferous woods.
Corner Brook 25Jul92♀; Corner Brook 14Jun93♂.

Gonatium crassipalpum Bryant, 1933
Nearctic. Coastal rocky barrens; *Empetrum* barrens; sphagnum bogs.
Berry Head Pond (GMNP) 19Jul00♀; Logy Bay 20Nov03♀; Point Riche 13Jul99♂; St. Lunaire 15Aug00♀; Table Point 30Sep98♂.

Grammonota angusta Dondale, 1959 [H; *Grammonota pictilis* (O. Pickard-Cambridge, 1875)]
Nearctic. Mixed coniferous woods; low vegetation in clearings in woods. Common.
Gadds Harbour 27Jul97♀♀; Gallows Cove 10Aug99♀♀; Gander 28Jul98♂♂; Port au Choix 8Jul00♀; Stuckless Pond 20Jul93♂.

Grammonota capitata Emerton, 1924 [H; *Grammonota pictilis* (O. Pickard-Cambridge, 1875) in part]
Nearctic. Mixed coniferous woods.
South Branch (Codroy) 3Jul49♀ (FMNH); Spruce Brook River 8-9Jul49♀♀ (FMNH); Victoria Lake 13Jun51♀ (FMNH).

Grammonota gigas (Banks, 1896) [H]
Nearctic. Mixed coniferous woods; sphagnum bogs.
Bakers Brook estuary 14Jul98♀♀; Rocky Harbour (Bottom Brook bog) 13Aug98♀; Main River west 00Jul98♀♂; Mount Scio 00Aug95♀.

Grammonota maritima Emerton, 1925 [H]
Nearctic. *Empetrum* barrens; rocky coastal barrens.
Burnt Cape 00Aug03♀♂.

Grammonota vittata Barrows, 1919
Nearctic. Low vegetation in and around sphagnum bogs.
Rocky Harbour (Bottom Brook bog) 16Jul99♂.

Halorates alascensis (Banks, 1900) [H; *Collinsia clypiella* (Chamberlin, 1920)]
Nearctic. Salt marshes; wet *Empetrum* barrens.
Cow Head 10Aug49♀ (FMNH?); Deer Lake 30May51♀♀♂♂ (FMNH?). Not found by CDD in Hackman's collections in FMNH. This record may be erroneous but is retained here pending clarification.

Halorates holmgrenii (Thorell, 1871)
Holarctic. Exposed coastal barrens.
Big Brook 19Jun02♀.

Halorates palmeni (Hackman, 1954) [H; *Collinsia palmeni* Hackman]
Known only from a single female reported by Hackman (1954)
Nearctic. River bank.
South Branch (Codroy) 2Jul49♀ (CNC).
Note: CDD and J. Redner examined this specimen and think it is *Oedothorax maximus* (Emerton); this question will be dealt with elsewhere.

Halorates pertinens (O. Pickard-Cambridge, 1875) [H; *Collinsia pertinens* O. Pickard-Cambridge]
Nearctic. Among stones and litter at the back of beaches.
Big Brook 18Jun02♀♂♂; Gadds Harbour 11Aug99♀.

Helophora insignis (Blackwall, 1841) [H]
Holarctic. Mixed coniferous woods.
Bakers Brook estuary 27Aug00♀.

Hilaira canaliculata (Emerton, 1915) [H; *Hilaira aquilonia* Hackman, 1954]
Holarctic. In litter and moss in thickets of shrubs.
Stanford River 11Aug49♀♀ (CNC).

Hilaira herniosa (Thorell, 1875) [H]
Holarctic. Exposed coastal *Empetrum* barrens.
Raleigh 17Jul48♀ (FMNH).

Hybauchenidium gibbosum (Sørensen, 1898) [H; *Hybocoptus denticulatus* (Emerton, 1915)]
Nearctic. Mixed coniferous woods.
Main River west 00Jun98♀♂.

Hypomma marxii (Keyserling, 1886) [H]
Nearctic. *Empetrum* barrens; sphagnum bogs.
Cow Head 11Aug49♀ (FMNH); South Branch (Codroy) 2Jul49♀ (FMNH); Victoria Lake 11Jun51♀♀ (FMNH).

Islandiana flaveola (Banks, 1892)
Nearctic. Mixed coniferous woods.
Main River west 31Jul00♂.

Islandiana holmi Ivie, 1965 [H; *Islandiana alata* (Emerton, 1919)]
Nearctic. *Empetrum* and rocky barrens at the coast and higher altitudes.
Bartletts Harbour 12Jul04♀; Port au Choix 5 Jul04♀.

Islandiana princeps Braendegaard, 1932 [H; *Islandiana alata* (Emerton, 1919)]
Nearctic. Sphagnum bogs; *Empetrum* barrens.
Big Brook 22Jun02♂; Burnt Cape 00Aug03♀♂; Sally's Cove bog 27Jul99♂.

Kaestneria pullata (O. Pickard-Cambridge, 1863) [H; *Bathyphantes pullatus* (O. Pickard-Cambridge)]
Holarctic. Shrubs and herbs in mixed coniferous woods; shrubs and herbs in road cuttings.
Bellburns 8Jul97♀; Port au Choix 20Jul99♀; Sally's Cove 31Jul-15Aug00♂; Shallow Bay 9Aug98♀; TNNP 10Jun93♂.

Kaestneria rufula (Hackman, 1954) [H; *Bathyphantes rufulus* Hackman]
Nearctic. Sphagnum bogs.
Bakers Brook estuary 3Jul98♀.

Lepthyphantes alpinus (Emerton, 1882) [H]
Holarctic. Mixed coniferous woods.
Gander 20Jul98♀♂♂; Killdevil Mountain 20Jul00♀♀♂♂; Norris Point 27Jul98♀; Point Riche 1Aug99♀♀♂; Port au Choix 1Aug99♀♂; Stanford River 29Jul99♀♂.

Lepthyphantes bihamatus (Emerton, 1882) [H]
Nearctic. Mixed coniferous woods; low herbs in clearings in woods.
Berry Head Pond (GMNP) 4Aug99♂; Lobster Cove 22Jul99♂; Norris Point 14Aug00♂; Port au Choix 12Jul99♀; Shallow Bay 13Jul97♂.

Lepthyphantes calcaratus (Emerton, 1909) [H]
Nearctic. Mixed coniferous woods; stunted trees near coast; sea-cliffs.
Berry Head Pond (GMNP) 24Jul99♀; Green Gardens 00Aug92♂; base of Killdevil Mountain 20Jul00♀; Lobster Cove 9Aug99♂♂; Point Riche 24Jul98♂.

Lepthyphantes complicatus (Emerton, 1882) [H; *Lepthyphantes umbraticola* (Keyserling, 1886)]
Holarctic. Mixed coniferous woods; coastal rocky and *Empetrum* barrens.
Big Brook 19Jun99♀♂; Nameless Cove 16Aug01♀; Point Riche 13Jul99♂; Port au Choix 1Aug99♂; Savage Cove 23Aug98♀.

Lepthyphantes cracens Zorsch, 1937. [H; *Lepthypantes nigriventris* (L. Koch, 1879)]
Nearctic. Mixed coniferous woods.
Previously reported only from New York State (Buckle et al. 2001) and Quebec (Paquin & Dupérré 2003 as *Tenuiphantes*) on the basis of males. Both males and females have been found in Newfoundland, and the female has been described elsewhere (Pickavance 2004). The female is similar to *L. nigriventris* (L. Koch, 1879), and likely Hackman's (1954) report of a single female of this Palaearctic species from Newfoundland was a misidentification of a specimen of *L. cracens*. We feel that *L. nigriventris* probably does not occur in North America.
Port au Choix 2-11Aug00♀♀♂♂, 20Aug00♀♀♂♂ (and CNC).

Lepthyphantes duplicatus (Emerton, 1913) [H; *Lepthyphantes triramus* Chamberlin & Ivie, 1947]
Nearctic. Mixed coniferous woods.
Bakers Brook estuary 8-27Aug♀♂; Little Grand Lake 6Aug 94♀; Norris Point 15Aug00♀; Port au Choix 8- 24Jul00♂.

Lepthyphantes intricatus (Emerton, 1911)
Nearctic. Mixed coniferous woods.
Main River west 00Jul98♂.

Lepthyphantes leprosus (Ohlert, 1865) [H]
Palaearctic; introduced. Mixed coniferous woods; sea cliffs; houses and outbuildings.
Blackhead (St. John's) 12Nov02♀; Mt. Scio 8Oct99♀; Port au Choix 1Oct98♂; St. John's 2Nov02♂; Tuckers Head 3Oct98♀.

Lepthyphantes tenuis (Blackwall, 1852)
Palaearctic; introduced. Coastal *Empetrum* barrens near human settlements.
Blackhead (St. John's) 12Nov02♂♂; Logy Bay 16Sep03♀.

Lepthyphantes turbatrix (O. Pickard-Cambridge, 1877) [H; *Lepthyphantes subalpinus* (Emerton, 1882)]
Nearctic. Mixed coniferous woods; stones at the back of beaches; sea cliffs; talus slopes.
Boutitou 17Jul03♀; Conche 16Jul03♀♀; Gander 26Jul98♂; Lomond 12Aug93♂; Tuckers Head 30Jul97♀♀♂.

Lepthyphantes washingtoni Zorsch, 1937
Nearctic. Rocky or *Empetrum* barrens; mixed coniferous woods.
Big Brook 20-25Jun03♀♀; Main River west 00Jul00♀; Nameless Cove 16Aug01♀; Point Riche 25Jun00♀; Port au Choix 3-11Aug♀♂.

Lepthyphantes zebra (Emerton, 1882) [H]
Nearctic. Mixed coniferous woods.
Logy Bay 6Oct02♀.

Lepthyphantes spp.
Two unidentified species. In CNC as *Lepthyphantes* #2, *Lepthyphantes* #7.
Nearctic. Mixed coniferous woods.
#2 Berry Head Pond (GMNP) 24Jul99♀ (and CNC); #7 Glide Lake 00Jul94♂♂; Main River west 1Aug00♀ (and CNC).

Lophomma sylvaticum (Emerton, 1913) [H; a specimen of this species labelled *Entelecara* is in Hackman's material in FMNH, but is not recorded in his list of species]
Nearctic. Mixed coniferous woods.
Main River west 00Jul98♀♂.

Maro amplus Dondale & Buckle, 2001
Nearctic. Mixed coniferous woods; shrubs and herbs in clearings in woods.
Corner Brook 24Jul92♂; Main River west 17Jun98♂♂; Mt. Scio 00Aug95♂ (and CNC); Glide Lake 00Jul94♂♂.

Maro nearcticus Dondale & Buckle, 2001
Nearctic. Mixed coniferous woods.
Little Grand Lake 15Jul92♀, 13Jul93♀♀; Main River west 27Jul00♀; Stanford River 29Jul99♀.

Maso sundevallii (Westring, 1851) [H]
Holarctic. Mixed coniferous woods.
Main River west 00Jul98♂.

Mecynargus paetulus (O. Pickard-Cambridge, 1875).
Holarctic. Coastal subarctic barrens.
Nameless Cove16Aug01♀; Savage Cove 30Jun03♀.

Micrargus longitarsus (Emerton, 1882)
Nearctic. Mixed coniferous woods.
Corner Brook 7Aug93♂.

Microlinyphia mandibulata (Emerton, 1882) [H; *Pusillia mandibulata* Emerton]
Nearctic. Coastal *Empetrum* barrens; moist abandoned meadows.
Badger 24Jun80♀; Blackhead (St. John's) 10Jun01♂; Logy Bay 6Aug01♀; Main River west 14Aug00♀.

Mythoplastoides exiguus (Banks, 1892) [H; *Entelecara exigua* (Banks)]
Nearctic. Sphagnum bogs.
Pushthrough 24Jun49♀♀ (FMNH?). Not found by CDD in Hackman's collections in FMNH. This record may be erroneous but is retained here pending clarification.

Neriene clathrata (Sundevall, 1830) [H; *Linyphia waldea* Chamberlin & Ivie, 1943]
Holarctic. Mixed coniferous woods; coastal abandoned meadows; shrubs in road cuttings.
Bay Bulls 1May96♂; Blackhead (St. John's) 9Jun03♂; Gander 28Jul98♀; Gros Morne Mountain 16Jun94♀; Norris Point 7Jul00♂.

Neriene radiata (Walckenaer, 1841) [H; *Linyphia marginata* C. L. Koch, 1834]
Holarctic. Mixed coniferous woods; sea cliffs; shrubs in road cuttings.
Gander 28Jul98♂♂; Rocky Harbour 30Jul97♀; Tuckers Head 30Jul97♀.

Oedothorax trilobatus (Banks, 1896)
Nearctic. Mixed coniferous woods; sphagnum bogs; rocky barrens.
Bakers Brook estuary ♀; Berry Head Pond (GMNP) 22Aug 00♀♀; Rocky Harbour (Bottom Brook bog) 23Jul99♀; Eddies Cove East 21Jun00♀♂; Main River west 20Jul00♂.

Oreonetides flavescens (Crosby, 1937) [H]
Nearctic. Sphagnum bogs.
Rocky Harbour (Bottom Brook bog) 5Aug98♀.

Oreonetides rectangulatus (Emerton, 1913)
Nearctic. Sphagnum bogs.
Berry Head Pond (GMNP) 15-22Aug00♀♀♂♂; Rocky Harbour (Bottom Brook bog) 23Jul-20Aug99♀♂; Sally's Cove 6-21Jul00♂♂.

Oreonetides rotundus (Emerton, 1913) [H; *Diplocentria corynetes* Chamberlin & Ivie, 1945]
Nearctic. Mixed coniferous woods.
Gallows Cove 2Nov97♀; Glide Lake 00Aug94♂; Main River west 00Jul98♀; Norris Point 28Jul98♀♂.

Oreonetides vaginatus (Thorell, 1872) [H]
Holarctic. Mixed coniferous woods.
Glide Lake 00Aug96♀♂; Main River west 00Jul98♂; Port au Choix 8Jul00♂.

Oreonetides spp.
Two unidentified species. In CNC as *Oreonetides* #1 and *Oreonetides* #2
Nearctic. Mixed coniferous woods.
#1 Norris Point 28Jul98♀, 20Jun-13Jul00♀♀; #2 Glide Lake 00Aug96♂.

Oreophantes recurvatus (Emerton, 1913)
Nearctic. Mixed coniferous woods.
Bakers Brook estuary 8-27Aug00♀♂; Berry Head Pond (GMNP) 26Jul00♂; Glide Lake 00Aug96♂; Little Grand Lake 27Jul94♀.

Pelecopsis mengei (Simon, 1884) [H; *Trichopterna mengei* (Simon)]
Holarctic. Mixed coniferous woods.
Burnt Cape 00Aug03♀; Main River west 00Jul98♀♂.

Pityohyphantes costatus (Hentz, 1850) [H; *Pityohyphantes costata* Hentz]
Nearctic. Mixed coniferous woods.
Deer Lake 3Jun51♀ (FMNH); Hare Bay 21Jun49♀ (FMNH); Lomond 14Jul49♀ (FMNH); Rencontre 17-19Jun49♂ (FMNH); Spruce Brook 8-9Jul49♂ (FMNH).

Pityohyphantes limitaneus (Emerton, 1915)
Nearctic. Mixed coniferous woods.
Berry Head Pond (GMNP) 29Jun00♀♀♂♂; Lomond 14Jul98♀♀; Millbrook (Rocky Harbour) 4Aug97♀♀.

Pityohyphantes subarcticus Chamberlin & Ivie, 1943 [H; *Pityohyphantes costata* Hentz, 1850]
Nearctic. Mixed coniferous woods; rocky barrens.
Bakers Brook estuary 8-27Aug00♀♂; Eddies Cove East 21Jun00♀; Gander 28Jul98♀♀; Main River west 28Jul00♀♀; Port au Choix 24Jul00♂.

Pocadicnemis americana Millidge, 1976
Nearctic. Mixed coniferous woods; rocky barrens; stones and litter at back of beaches.
Bakers Brook estuary 6Aug99♀; Burnt Cape 00Aug03♀; Gander 28Jul98♀♂; Little Grand Lake 22Aug94♀; Mt. Scio 00Aug95♂.

Poeciloneta furcata (Emerton, 1913)
Nearctic. Mixed coniferous woods.
Little Grand Lake 24Aug93♂.

Poeciloneta sp.
Unidentified species. NF 017 male and NF 108 female.
Nearctic. Mixed coniferous woods.
NF017 Corner Brook 19Jul-17Aug93♂ (CNC); NF108 Corner Brook 10-23Aug94♀ (CNC).

Porrhomma gertschi Hackman, 1954 [H]
Nearctic. Mixed coniferous woods.
Known only from Newfoundland.
Deer Lake 30May51♀♂ (CNC).

Porrhomma terrestre (Emerton, 1882)
Nearctic. Mixed coniferous woods.
Berry Head Pond (GMNP) 16Aug99♂, 26Jul-4Aug00♂; Corner Brook 14Jun-6Jul93♀♂, 19Jul-17Aug93♀; base of Killdevil Mountain 20Jul00♀.

Porrhomma sp.
Unidentified species: *Porrhomma* sp. #1
Nearctic. Mixed coniferous woods.
Glide Lake 00Jul94♀; Corner Brook 25Jul92♀.

Satilatlas gertschi Millidge, 1981
Nearctic. Exposed coastal barrens.
Burnt Cape 00Jul03♂.

Satilatlas marxii Keyserling, 1886
Holarctic. Mixed coniferous woods; *Empetrum* barrens.
Burnt Cape 00Jul03♀♀; Eddies Cove East 21Jun00♀♀; Main River west 00Jul98♀.

Sciastes dubius (Hackman, 1954) [H; *Hilaira dubia* Hackman]
Holarctic. Mixed coniferous woods; damp moss.
Grandy Brook 26Jun49♀♀ (FMNH); Rose Blanche 27Jun49♀ (FMNH); St. Barbe 26Jul49♀ (FMNH); Stanford River 11Aug49♀ (CNC); Victoria Lake 11- 13Jun51♀ (FMNH).

Sciastes truncatus (Emerton, 1882) [H]
Nearctic. Mixed coniferous woods.
Gander 28Jun98♂; Glide Lake 00Jul94♂; Main River west 00Jul98♂; Norris Point 27Jul98♀, 26Jul00♂♂.

Scirites pectinatus (Emerton, 1911) [H; *Tapinocyba exigua* Hackman, 1954]

Nearctic. Mixed coniferous woods; birch stands.
Millertown Junction 22Aug49♀ (CNC).

Scironis tarsalis (Emerton, 1911) [H]
Nearctic. Mixed coniferous woods; alder thickets.
Little Grand Lake 27Jul94♂.

Scotinotylus pallidus (Emerton, 1882)
Nearctic. Sphagnum bogs; *Empetrum* barrens.
Baie Verte Peninsula 22Oct85♀ (CNC); Main River 16Aug85♀ ♀♂ (CNC); Pasadena 13, 19Jul84♀♀♂♂ (CNC); Pinchgut Lake 17Aug84♀ (CNC); Plumb (=Plum) Point 18Oct85♀ (CNC).

Scotinotylus sacer (Crosby, 1929)
Holarctic. Mixed coniferous woods; sphagnum bogs.
Gander 28Jun98♂; Glide Lake 00Jul94♂; Main River west 00Jul98♂; Norris Point 27Jul98♀, 27Jun-26Jul00♀♂♂.

Scyletria inflata Bishop & Crosby, 1938
Nearctic. Mixed coniferous woods.
Main River west 22Jul00♂; Burnt Cape 00Aug03♂.

Semljicola obtusus (Emerton, 1915)
Nearctic. Mixed coniferous woods; *Empetrum* barrens.
Main River west 22Jul00♀; Burnt Cape 00Aug03♂.

Sisicottus montanus (Emerton, 1882) [H]
Nearctic. Mixed coniferous woods. Common.
Berry Head Pond (GMNP) 27Jul-16Aug99♀♂; Big Brook 22-24Jun02♀♂; Gander 1Jul78♀; Lobster Cove 20Aug99 ♀ ♂♂; Port au Choix 1Aug99♂.

Sisicottus quoylei Miller, 1999
Nearctic. Mixed coniferous woods.
Logy Bay 11Jul02♂; Long Pond (St. John's) 10Jan99♀♂; Main River west 00Jul98♂.

Sisicus apertus (Holm, 1939)
Holarctic. Mixed coniferous woods.
Bakers Brook estuary 8-27Aug00♀♂; Corner Brook 25Jul92♀♂; Glide Lake 00Jul94♂.

Sisicus penifusifer Bishop & Crosby, 1938
Nearctic. Sphagnum bogs.
Rocky Harbour (Bottom Brook bog) 13Jul98♀.

Sisis rotundus (Emerton, 1925)
Nearctic. Mixed coniferous woods.
Glide Lake 00Jul94♂; Main River west 00Jul98♀♂.

Souessa spinifera (O. Pickard-Cambridge, 1874) [H]
Nearctic. Mixed coniferous woods.
Grandy Brook, Cow Head, Stanford River, Gambo: 21-30Jun49♀; 21-31Jul49♀; 1-31Aug49♀♀ (FMNH?). Dates not connected to localities; year assumed 1949 from context (Hackman 1954). Not found by CDD in Hackman's collections in FMNH. This record may be erroneous but is retained here pending clarification.

Sougambus bostoniensis (Emerton, 1882) [H; *Hilaira algida* Hackman, 1954]
Nearctic. Mixed coniferous woods.
Grand Bruit 13Jun49♀♀ (FMNH and CNC); Lomond 15Jul49♀ (FMNH).

Soulgas corticarius (Emerton, 1909)
Nearctic. Mixed coniferous woods; litter at back of beaches.
Bakers Brook estuary 27Aug98♀.

Stemonyphantes blauveltae Gertsch, 1951
Nearctic. Mixed coniferous woods; *Empetrum* barrens.
Cupids 5Sep99♀; Logy Bay 11Nov02♂; Long Pond (St. John's) 12May80♀; Mt. Scio 00Aug95♀; St. John's 21Feb99♂.

Styloctetor stativus (Simon, 1881) [H; *Spirembolus oreinoides* Chamberlin, 1948]
Nearctic. Mixed coniferous woods.
Kittys Brook 18Aug49♀ (FMNH?).
Not found by CDD in Hackman's collections in FMNH. This record may be erroneous but is retained here pending clarification.

Tapinocyba bicarinata (Emerton, 1913)
Nearctic. Mixed coniferous woods.
Burnt Cape 00Aug03♂; Main River west 00Jul98♂.

Tapinocyba flagellata (Emerton, 1911)
Nearctic. Mixed coniferous woods.
Grandys Lake north 20Sep84♂ (CNC); Barachois Brook 15Aug84♀ (CNC).

Tapinocyba lindrothi Hackman, 1954 [H]
Nearctic. Mixed coniferous woods.
South Branch (Codroy) 3Jul49♀ (CNC).

Tapinocyba minuta (Emerton, 1909)
Nearctic. Alpine *Empetrum* barrens; sphagnum bogs.
Burnt Cape 00Aug03♀♀♂♂; Killdevil Mountain 17Aug99♀ ♂♂; Point Riche 24Jul00♂; Sally's Cove 27Jul99♂.

Tapinocyba simplex (Emerton, 1882) [H]
Nearctic. Mixed coniferous woods.
Bakers Brook estuary 8-27Aug00♀♂; Glide Lake 00Jul94♀ ♂; Lobster Cove 21Aug98♀; Stanford River 29Jul99♀♂.

Tapinopa bilineata Banks, 1893
Nearctic. Litter at back of beach.
Bakers Brook estuary 8-27Aug♀; Blackhead (St. John's) 12Nov02♀; Green Point 26Aug98♀.

Tennesseellum formicum (Emerton, 1882)
Nearctic. Mixed coniferous woods.
Main River west 31 Jul00♂; Norris Point 11Aug99♀.

Thyreosthenius parasiticus (Westring, 1851) [H]
Holarctic. Mixed coniferous woods.
Norris Point 28Jun-22Jul00♀♂.

Tiso vagans (Blackwall, 1834)
Palaearctic; introduced. Coastal *Empetrum* barrens.
Blackhead (St. John's) 31May02♀♂.

Tunagyna debilis (Banks, 1892) [H]
Holarctic. Mixed coniferous woods; *Empetrum* barrens; shrubs at lower elevations of mountains.
Big Brook 25Jun02♀♀♂♂; Blackhead (St. John's) 21Apr99♂; Nameless Cove 16Aug01♀♀; Port au Choix1Aug99♂; Table Point 23Jul97♀.

Typhocrestus pygmaeus (Sørensen, 1898)
Nearctic. Exposed coastal barrens.
Burnt Cape 00Jul03♂.

Vermontia thoracica (Emerton, 1913)
Holarctic. Mixed coniferous woods.
Main River west 00Jul98♀♂.

Wabasso cacuminatus Millidge, 1984
Holarctic. Mixed coniferous woods.
Main River west 00Jul98♂.

Wabasso quaestio (Chamberlin, 1949)
Holarctic. Mixed coniferous woods; rocky coastal barrens.
Big Brook 21Jun02♂; Burnt Cape 00Aug03♀♂; Main River west 00Jul98♂♂.

Walckenaria arctica Millidge, 1983 [H; *Oedothorax montiferus* (Emerton, 1882)]
Nearctic. Mixed coniferous woods.
Bakers Brook estuary 8-27Aug00♀♂; Berry Head Pond (GMNP) 27Jul99♂; Glide Lake 00Jul94♂.

Walckenaria atrotibialis (O. Pickard-Cambridge, 1878) [H; *Entelecara abrupta* (Emerton, 1909)]
Holarctic. Mixed coniferous woods.
Bakers Brook estuary 8-27Aug00♀♂; Berry Head Pond (GMNP) 28Jul99♂; Norris Point 26Jul-14Aug00♂♂; Port au Choix 1Aug99♀; Sally's Cove 31Jul00♂.

Walckenaeria auranticeps (Emerton, 1882) [H; *Cornicularia auranticeps* Emerton, 1882]
Holarctic. Mixed coniferous woods.
Gaff Topsail 20Aug49♀ (FMNH).

Walckenaeria castanea (Emerton, 1882) [H; *Trachynella nudipalpis* (Westring, 1851), *Minyriolus castaneus* (Emerton)]
Nearctic. Mixed coniferous woods; coastal *Empetrum* barrens; sphagnum bogs.
Berry Head Pond (GMNP) 28Jul-10Aug99♀♂; Big Brook 22Jun02♀♀; Rocky Harbour (Bottom Brook bog) 10Aug99♀; Point Riche 13Jul99♀♀; Port au Choix 8Jul00♀♂.

Walckenaeria clavipalpis Millidge, 1983
Nearctic. Mixed coniferous woods.
Main River west 00Jul98♂♂; Port au Choix 13Jul- 1Aug99♀♂, 24Jul00♂; Stanford River 29Jul99♀.

Walckenaeria communis (Emerton, 1882)
Nearctic. Coastal rocky barrens; sphagnum bogs; mixed coniferous woods.
Big Brook 20Jun02♀; Burnt Cape 00Aug03♀♂; Eddies Cove East 21Jun00♀; Point Riche 8-24Jul00♀♀; Sally's Cove 27Jul99♀.

Walckenaeria cuspidata (Crosby & Bishop, 1931) [H; *Cornicularia cuspidata* Crosby & Bishop)]
Nearctic. Rocky barrens; back of beaches.
Big Brook 18Jun02♀♀; Nameless Cove 16Aug01♀; Savage Cove 14Jul01♀.

Walckenaeria digitata (Emerton, 1913)
Nearctic. Mixed coniferous woods.
Main River west 22Jul00♂.

Walckenaeria directa (O. Pickard-Cambridge, 1874)
Nearctic. Mixed coniferous woods.
Norris Point 13Jul00♀.

Walckenaeria exigua Millidge, 1983 [H; *Cornicularia minuta* Emerton, 1882]
Nearctic. Mixed coniferous woods; sphagnum bogs.
Berry Head Pond (GMNP) 4Aug99♂; Rocky Harbour (Bottom Brook bog) 13Aug98♀; Gander 28Jul98♂♂; Glide Lake 00Jul94♀♂; Point Riche 3Aug00♀.

Walckenaeria karpinskii (O. Pickard-Cambridge, 1873) [H; *Cornicularia karpinskii* (O. Pickard-Cambridge)]
Holarctic. Mixed coniferous woods.
Big Brook 16Jul01♀♀, 18Jul02♂; Burnt Cape 00Aug03♀♂; Cape Raven 15Aug99♂; Main River west 00Jul98♀♂.

Walckenaeria lepida (Kulczyński, 1885) [H; *Cornicularia unicornis* (O. Pickard-Cambridge, 1861)]
Holarctic. Mixed coniferous woods.
Noel Pauls Brook 26Jun77♀ (CNC).

Walckenaeria pallida (Emerton, 1882)
Nearctic. Mixed coniferous woods.
Norris Point 27Jul00♀.

Walckenaeria palustris Millidge, 1983
Nearctic. Mixed coniferous woods.
Stanford River 29Jul99♀.

Walckenaeria redneri Millidge, 1983
Nearctic. Mixed coniferous woods.
Main River west 00Jul98♂♂.

Walckenaria spiralis (Emerton, 1882) [H; *Cornicularia vigilax* (Blackwall, 1853)]
Holarctic. Sphagnum bogs; mixed coniferous woods.
Bakers Brook estuary 3Jul98♀; Rocky Harbour (Bottom Brook bog) 20Aug99♀; Burnt Cape 00Aug03♀♂; Mt. Scio 00Aug95♂.

Walckenaeria tricornis (Emerton, 1882) [H; *Tigellinus tricornis* (Emerton)]
Nearctic. Mixed coniferous woods.
Burnt Cape 00Aug03♂; Main River west 00Jul98♂; Stanford River 29Jul99♂.

Wubana drassoides (Emerton, 1882)
Nearctic. Mixed coniferous woods.
This record is from a single female. Identification of isolated females in this genus is difficult. Retained here as a Newfoundland record pending confirmation by a male.
Tuckers Head 3Oct98♀.

Wubana pacifica (Banks, 1896)
Nearctic. Mixed coniferous woods.
A record based on both males and females.
Big Brook 22Jun02♂; Burnt Cape 00Aug03♀; Corner Brook 13Jul93♀; Norris Point 29Jun-25Aug♀♂.

Zornella cultrigera (L. Koch, 1879) [H].
Holarctic. Mixed coniferous woods.
Nearctic records of *Zornella* are likely an undescribed species (Buckle et al. 2001), but the name is retained here pending revision of the genus.
Main River west 00Jul98♀.

Linyphiidae CNC#76
Not attributed to genus or species
Mixed coniferous woods.
Corner Brook 25Jul92♀; Glide Lake 00Jul94♀; Main River west 00Jul99♀.

LIOCRANIDAE (1 sp.)
Agroeca ornata Banks, 1892.
Holarctic. Mixed coniferous woods.
Big Brook 21Jun02♀; Burnt Cape 00Aug03♀♂; Gander 28Jul98♀; Glide Lake 00Jul96♀♀; Main River west 00Jul98♀.

LYCOSIDAE (24 spp.)
Alopecosa aculeata (Clerck, 1758) [H]
Holarctic. Rocky and *Empetrum* barrens; sphagnum bogs.
Brunette Island 22Jun80♂; Burnt Cape 00Aug03♀♂; Cape Race 11Jun95♂; Hawke Hills 2Jun95♀♀♂♂; Point Riche 4Aug00♀♀.

Arctosa alpigena (Doleschall, 1852) [H]
Holarctic. Exposed coastal *Empetrum* barrens; tops of the Long Range Mountains.
Big Brook 22Jun02♀♂; Burnt Cape 00Aug03♀♀♂♂; Gros Morne Mountain 17Aug94♀; Killdevil Mountain 17Aug99♀♀; Watts Point 9Aug95♂♂.

Arctosa insignita (Thorell, 1872)
Holarctic. Mixed coniferous woods.
Main River west 00Aug98♂.

Arctosa lama Dondale & Redner, 1983 [H; *Arctosa virgo* (Chamberlin, 1925)]
Nearctic. Sphagnum bogs.
Grandy Brook 25Jun49♂ (FMNH).

Arctosa raptor (Kulczyński, 1885) [H; *Arctosa quinaria* (Emerton, 1895)]
Holarctic. Mixed coniferous woods; sphagnum bogs.
Glide Lake 19Aug84♀ (CNC); North Arm Mountain (Bonne Bay) 13Aug87♀♀ (CNC). Cow Head, Grand Bank, Lomond: 11-20Jun49♂; 1-31Jul49♀♀♂♂; 1-31Aug♀♀♂ (FMNH). Dates not connected to localities; year assumed 1949 from context (Hackman 1954).

Arctosa rubicunda (Keyserling, 1877) [H; *Arctosa emertoni* Gertsch, 1934]
Nearctic. Sphagnum bogs.
Cape Ray 1Jul96♀♀(and CNC).

Pardosa albomaculata Emerton, 1885
Nearctic. Talus and mixed vegetation at higher elevations of the Long Range Mountains.
Gros Morne Mountain 8Oct94♀; Tablelands 15Aug92♀.

Pardosa concinna (Thorell, 1877) [H]
Nearctic. Exposed coastal *Empetrum* barrens. Common.
Cape Onion 4Aug96♀♀; Cape Ray 1Jul96♂; Cape Spear 3Sep 95♀♂; Point Riche 17Aug98♀♀♂♂; Watts Point 1Aug95♀♂.

Pardosa furcifera (Thorell, 1875) [H]
Nearctic. *Empetrum* barrens on exposed coasts and at higher elevations.
Big Brook 21Jun02♀♀; Killdevil Mountain 17Aug99♀♂; Nameless Cove 16Aug01♀; Savage Cove 14Jul01♂; Watts Point 19Aug95♀♀♂♂.

Pardosa fuscula (Thorell, 1875) [H]
Nearctic. Sphagnum bogs.
Bay Bulls 15Aug96♀♂; Big Brook 21Jun02♀; Burnt Cape 00Aug03♀♀♂♂; Cape Freels 12Jul01; Cape Ray 1Jul96♀.

Pardosa groenlandica (Thorell, 1872) [H]
Nearctic. Cobble and pebble beaches. In NF rarely found away from the coast. Common.
Bay Bulls 1May96♂; Bristols Hope 11Nov94♀; Conche 16Jul03♀; Port au Port Peninsula♀♂; St. Pauls 6Aug95♀.

Pardosa hyperborea (Thorell, 1872) [H; *Pardosa saltuaria* (L. Koch, 1870)]
Holarctic. Mixed coniferous woods; *Empetrum* barrens; sphagnum bogs. Common.
Boutitou 17Jul03♂; Cape Ray 1Jul96♀♀♂♂; Cape Spear 3Sep95♀♂; Hawke Hills 2Jun95♀♂; Killdevil Mountain 17Aug99♀♀.

Pardosa lapidicina Emerton, 1885 [H]
Nearctic. Talus slopes of the Long Range Mountains.
Gros Morne Mountain 31Jul95♀; Killdevil Mountain 2Jul95♀; Tablelands 11Aug94♀.

Pardosa mackenziana (Keyserling, 1877) [H]
Nearctic. Mixed coniferous woods.
Bakers Brook 8-27Aug00♀♂; Gander 1Jul79♂; Glide Lake 8-22Jul♀♂; Port au Choix13Jul99♀; Woody Point 9Oct94♀.

Pardosa moesta Banks, 1892 [H]
Nearctic. Coastal and inland *Empetrum* barrens.
Cape Spear 3Sep95♀♀; Gander 21Jun98♂♂; Green Gardens 18Jun94♀♀♂♂; Hawke Hills 2Jun95♀♂; Port au Choix 6Aug96♀♀.

Pardosa xerampelina (Keyserling, 1877) [H]
Nearctic. Mixed coniferous woods; *Empetrum* barrens; sphagnum bogs.
Glide Lake 7Jul94♀♂; Green Gardens 7Jul97♀; Port au Choix 23Jul97♂; Tablelands 23Jul93♀♂; TNNP 11Jul93♀.

Pirata bryantae Kurata, 1944 [H]
Nearctic. Mixed coniferous woods.
Main River west 00Aug98♂.

Pirata canadensis Dondale & Redner, 1981
Nearctic. Mixed coniferous woods; sphagnum bogs.
Rocky Harbour (Bottom Brook bog) 29Jul98♀, 20Aug99♂; Main River west 00Jul98♂.

Pirata cantralli Wallace & Exline, 1978 [H; *Pirata insularis* Emerton, 1885]
Nearctic. Sphagnum bogs.
Cape Broyle, Gander, Grand Bruit, Pushthrough, Woody Point: 1-30Jun49♀♀♂♂; 1-31Jul49 ♀♀; 1-31Aug49♀♀ (FMNH). Dates not connected to localities; year assumed 1949 from context (Hackman 1954).

Pirata insularis Emerton, 1885 [H]
Holarctic. Sphagnum bogs.
Bakers Brook estuary 9Jul99♂; Berry Head Pond (GMNP) 22Aug00♀♂; Rocky Harbour (Bottom Brook bog) 23Jul99♀♂; Mt. Scio 00Aug95♂.

Pirata minutus Emerton, 1885 [H]
Nearctic. Mixed coniferous woods; sphagnum bogs.
Main River west 18Jun99♀.

Pirata montanus Emerton, 1885 [H]
Holarctic. Mixed coniferous woods; sphagnum bogs.
Base of Killdevil Mountain 13Jul49♀ (FMNH); East Brook (which one unspecified) 14Jul49♀♀ (FMNH).

Pirata piraticus (Clerck, 1758) [H]
Holarctic. Sphagnum bogs.
Bay Bulls 5Aug96♀; Big Brook 24Jun02♀♀♂♂; Cape Ray 1Jul96♀; Hawkes Bay 1Jul99♀.

Trochosa terricola Thorell, 1856 [H; *Trochosa terricola pratensis* Emerton, 1885]
Holarctic. Mixed coniferous woods; shrubs and herbs in clearings of woods; litter and stones at back of beaches; abandoned meadows; gardens. Common.
Brunette Island 22Jun80♂; Nameless Cove 16Aug01♀; Norris Point 9Aug95♀; Shallow Bay 27May96♀; St. John's 12May80♀♀.

MIMETIDAE (1 sp.)
Ero canionis Chamberlin & Ivie, 1935 [H]
Nearctic. Empetrum barrens; shrubs and herbs at edges of woods.
Point Riche 17Jul00♀.

NESTICIDAE (1 sp.)
Eidmanella pallida (Emerton, 1875) [H; *Nesticus pallida* Emerton]
Palaearctic; introduced. Mixed coniferous woods; caves; human habitations.
Corner Brook (in cave) 13Sep88♀ (CNC).

PHILODROMIDAE (7 spp.)
Philodromus alascensis Keyserling, 1884 [H; *Philodromus pernix* Blackwall, 1846]
Holarctic. Exposed coastal *Empetrum* barrens.
Boutitou 17Jul03♀.

Philodromus imbecillus Keyserling, 1880.
Nearctic. Mixed coniferous woods.
Bay d'Espoir 11Jul88♀♂♂ (CNC); Witch Hazel Ridge 25Jun81♀♀ (CNC).

Philodromus mysticus Dondale & Redner, 1975
Holarctic. Mixed coniferous woods.
Main River west 00Jul98♀.

Philodromus placidus Banks, 1892
Nearctic. Mixed coniferous woods.
Gander 00Aug98♂♂.

Philodromus rufus quartus Dondale & Redner, 1968 [H; *Philodromus rufus* Walckenaer, 1826]
Nearctic. Mixed coniferous woods; shrubs and herbs in clearings in woods.
Gadds Harbour 24Jul99♀; Gander 1Jul78♀♀♂; Logy Bay 8-23Jul01♀♂; Norris Point 3Jul00♂; Rocky Harbour 30Jul97♀.

Thanatus formicinus (Clerck, 1758) [H]
Holarctic. Exposed coastal rocky and *Empetrum* barrens.
Bay Bulls 4May96♂; Burnt Cape 00Aug03♀; Logy Bay 12Jun01♀; Table Point 3Aug95♀; Watts Point 9Aug95♀.

Tibellus maritimus (Menge, 1875) [H]
Holarctic. Coastal *Empetrum* barrens.
Bay Bulls 16Jul95♂; Logy Bay 8Jul01♂; Norris Point 3Jul00♂; St. John's 12May80♀; St. Lunaire 00Aug00♀.

PHOLCIDAE (1 sp.)
Pholcus phalangioides (Fuesslin, 1775)
Palaearctic; introduced. Houses in St. John's.
St. John's 15Aug00♀.

PISAURIDAE (1 sp.)
Dolomedes striatus Giebel, 1869 [H: *Dolomedes fulviatronatus* Bishop, 1924 and *Dolomedes vittatus* Walckenaer, 1837]
Nearctic. Edges of small pools; wet areas.
Come by Chance 27Aug49♀ (FMNH); Corner Brook 16Aug 49♀ (FMNH); East Brook, Lomond 15Jul49♀ (FMNH); Hogans Pond 6Jun49♀ (FMNH).

SALTICIDAE (15 spp.)
Chalcoscirtus alpicola (L. Koch, 1876)
Holarctic. Sub-arctic, exposed, coastal rocky and *Empetrum* barrens.
Big Brook16Jul01♂.

Dendryphantes nigromaculatus (Keyserling, 1885)
Nearctic. Exposed coastal barrens; exposed stunted woods.
Bay d'Espoir 15Jul85♀♀ (CNC).

Evarcha hoyi (Peckham & Peckham, 1883) [H]
Nearctic. *Empetrum* barrens; talus slopes.
Boutitou 17Jul03♂; Gander 00Aug98♂; Killdevil Mountain 9Aug94♂; Logy Bay 16Sep03♀; Main River west 29Jul00♂.

Ghelna canadensis (Banks, 1897)
Nearctic. Sphagnum bogs.
Bakers Brook estuary 19Aug99♀.

Neon nellii Peckham & Peckham, 1888 [H]
Nearctic. Rocky and *Empetrum* barrens.
Berry Head Pond (GMNP) 19Jul00♂; Logy Bay 18Jun01♂; Norris Point 28Jul00♂; Point Riche 17Jul00♀♀.

Pelegrina flavipes (Peckham & Peckham, 1888) [H; *Metaphidippus flavipedes* (Peckham & Peckham)]
Nearctic. Mixed coniferous woods; shrubs and herbs in clearings in woods.
Cupids 5Sep99♀♂; St. John's 8Sep98♂.

Pelegrina montana (Emerton, 1891) [H; *Metaphidippus montanus* (Emerton)]
Nearctic. *Empetrum* barrens; low vegetation.
Brunette Island 14Jul94♀; Gander 1Jul78♀♀; Millertown 26Jun80♀♀; St. John's 8Sep98♀.

Phidippus borealis Banks, 1895 [H; *Phidippus purpuratus* Keyserling, 1885]
Nearctic. Talus slopes and rocky barrens at low and medium elevations in the Long Range Mountains.
Tablelands 11Aug94♀; Winter House Brook canyon 10Jul97♂.

Phidippus whitmanii Peckham & Peckham, 1909 [H; *Phidippus princeps* (Peckham & Peckham, 1883]
Nearctic. *Empetrum* barrens; sphagnum bogs.
Rencontre West 15Jun49♀ (FMNH).

Salticus scenicus (Clerck, 1758) [H]
Palaearctic; introduced. On houses; *Empetrum* barrens; abandoned meadows; litter and stones at back of beaches.
Embree 12Nov 92♀; Clarkes Beach 24May98♂; Logy Bay 18Jun01♂♂; Norris Point 29Jul00♂; St. John's 2Jun93♂.

Sitticus cutleri Prószyński, 1980
Nearctic. Coastal *Empetrum* barrens.
Maddox Cove 1Jul94♂.

Sitticus finschii (L. Koch, 1879)
Holarctic. Mixed coniferous woods; sphagnum bogs.
Gander 00Aug02♂; Main River west 8Aug00♀.

Sitticus floricola palustris (Peckham & Peckham, 1883) [H; *Sitticus palustris* (Peckham & Peckham)]
Nearctic. Back of beaches; sand dunes; edge of lakes among driftwood.
Broom Point 16Jul98♀♂; Conche 27Jul04♀♂; Gadds Harbour 8Jul94♂♂; Outer Cove 3Aug96♂; St. Pauls 25Jul97♀♀.

Sitticus ranieri (Peckham & Peckham, 1909)
Holarctic. *Empetrum* barrens; talus slopes.
Gander 00Aug98♀♂♂; Logy Bay 12Jun01♀♂; Killdevil Mountain 17Aug99♂.

Sitticus striatus Emerton, 1911 [H]
Holarctic. Mixed coniferous woods; sphagnum bogs.
Blackhead (St. John's) 10Jun01♀; Lomond 14Jul98♀; Main River west 27Jul00♀♂.

TETRAGNATHIDAE (6 spp.)
Meta ovalis (Gertsch 1933) [H; *Meta menardi* (Latreille, 1804)]
Nearctic. Houses and outbuildings; basements; root cellars.
Colliers 14Dec04♀; Logy Bay 00May98♀; St. John's 00Jun 99♀.

Pachygnatha brevis Keyserling, 1884 [H]
Nearctic. Shrubs and herbs in damp places; near waterways.
St. John's 12may80♂♂.

Tetragnatha elongata Walckenaer, 1842 [H]
Nearctic. Shrubs and herbs in damp places; near waterways.
Portugal Cove 11Jul79♂.

Tetragnatha extensa (Linnaeus, 1758) [H]
Holarctic. Shrubs and herbs in damp places; near waterways; wetlands; herbs at back of beaches; road-cuttings.
Hawkes Bay 1Jul99♀♂; Plum Point 3Jul80♂; Port au Choix 4Aug97♀♂; Raleigh 4Aug98♀♂; Rocky Harbour 30Jul97♀.

Tetragnatha laboriosa Hentz, 1850 [H]
Nearctic. Shrubs and herbs in damp places; near waterways.
Rocky Harbour (Bottom Brook bog) 16Jul00♂; Gander 28Jul98♂.

Tetragnatha versicolor Walckenaer, 1842
Nearctic. Shrubs and herbs in damp places; near waterways.
Bakers Brook estuary 8-27Aug00♀♂; Berry Head Pond (GMNP) 24Jul99♂.

THERIDIIDAE (26 spp.)
Achaearanea ohlerti (Thorell, 1870)
Holarctic. Mixed coniferous woods.
Gadds Harbour 24Jul99♀.

Achaearanea tabulata Levi, 1980
Introduced; of unknown origin (Dondale et al. 1994).
In and on houses; on sheds and outbuildings; in gardens.
St. John's 24Sep99♀, 3Aug01♀, 23Aug01♀.

Achaearanea tepidariorum (C. L. Koch, 1841)
Introduced, of unknown origin; possibly tropical (Lindroth 1957).
In and on houses; on sheds and outbuildings; in gardens.
St. John's 3Aug01♂, 1May04♀♀.

Crustulina sticta (O. Pickard-Cambridge, 1861) [H; *Crustulina borealis* Banks, 1900]
Holarctic. Among stones at back of beaches; among stones on *Empetrum* barrens; among stones on sides and tops of mountains.
Eddies Cove East 21Jun01♀♀♂♂; Killdevil Mountain 17Aug 99♀♀; New Ferolle 16Jul00♀♀; Point Riche 29Jun99♀♂; Port au Choix5Jul04♀♀♂♂.

Dipoena nigra (Emerton, 1882)
Nearctic. Mixed coniferous woods; shrubs.
Gander 23Jun82♂ (CNC).

Enoplognatha caricis (Fickert, 1876) [H; *Theridion tectum* (Keyserling, 1884)]
Holarctic. Mixed coniferous woods; shrubs; rocky barrens; coastal *Empetrum* barrens.
Point Riche 17Jul00♀♀; Port au Choix 4Jul04♀♀(and CNC); Table Point 23Jul97♀♀ (and CNC).

Enoplognatha intrepida (Sørensen, 1898)
Nearctic. Exposed rocky and *Empetrum* barrens.
Burnt Cape 00Aug03♂♂; Cape Raven 15Aug99♀♂; Point Riche 24Jul98♀♂.

Enoplognatha marmorata (Hentz, 1850)
Nearctic. Mixed coniferous woods; sand dunes.
Cape Freels 10Jul01♂; Glide Lake 00Jul96♂; Table Point 18-30Jul00♂.

Enoplognatha ovata (Clerck, 1758)
Palaearctic; introduced. Shrubs and herbs; roadside vegetation; gardens; coastal barrens.
Gadds Harbour 24Jul99♀♀; Rocky Harbour 8Aug97♀; St. John's 27Aug97♀♀; Woody Point 8Aug93♀.

Neottiura bimaculata (Linnaeus, 1767)
Palaearctic; introduced. Mixed coniferous woods; gardens.
Gadds Harbour 24Jul99♀; Gander 00Jul98♂; Logy Bay 24Jul03♂.

Robertus banksi (Kaston, 1946) [H; *Ctenium banksi* Kaston]
Nearctic. Mixed coniferous woods.
Cow Head, Deer lake, Lomond, South Branch (Codroy), Stephenville Crossing: 1-20Jun49♀♀♂♂; 1-31Jul49♀♀; 11-20Aug49♀ (FMNH). Dates not connected to localities; year assumed 1949 from context (Hackman 1954).

Robertus borealis (Kaston, 1946) [H; *Ctenium boreale* Kaston]
Nearctic. Mixed coniferous woods.
Gaff Topsail 20Aug49♀ (FMNH); Cow Head 12Aug49♀ (FMNH); 40 miles west of St John's 6Aug76♀ (CNC).

Robertus fuscus (Emerton, 1894) [H; *Ctenium fuscum* (Emerton)]
Nearctic. *Empetrum* barrens; rocky barrens.
Boutitou 17Jul03♀; Main River west 00Jul98♂; Nameless Cove 16Aug01♀♀♂♂; Point Riche 17Aug98♀; Table Point 30Sep98♀.

Robertus riparius (Keyserling, 1886) [H; *Ctenium riparium* (Keyserling)]
Nearctic. Mixed coniferous woods.
Cinq Cerf Brook, Grand Bruit, Grandy Brook, South Branch (Codroy), Table Mountain (St. Georges): 11-20, 21-30Jun 49♀♀♂♂ (FMNH); 1-10, 11-20, 21- 31Jul49♀♀ (FMNH); 11-20Aug49♀ (FMNH). Dates not connected to localities; year assumed 1949 from context (Hackman 1954).

Rugathodes aurantius (Emerton, 1915) [H; *Theridion aurantium* Emerton]
Holarctic. Mixed coniferous woods.
Corner Brook 19Jul93♂; Port au Choix 24Jun00♂.

Rugathodes sexpunctatus (Emerton, 1882) [H; *Theridion sexpunctatum* Emerton]
Holarctic. Mixed coniferous woods; shrubs and herbs; gardens.
Berry Head Pond (GMNP) 4Aug99♀♀; Conche 16Jul03♀♀; base of Killdevil Mountain 20Jul00♀; Norris Point 13Aug 94♀; Port au Choix 24Jul00♂.

Steatoda bipunctata (Linnaeus, 1758) [H]
Palaearctic; introduced. On or near human structures: houses, basements, outbuildings and fences.
Corner Brook 8Jul99♀; Deer Lake 12Sep97♂; Dunville 25Apr97♂; Port au Choix 4Jul03♂; St. John's 10Jan02♀.

Theonoe stridula Crosby, 1906
Nearctic. Mixed coniferous woods; wetlands.
Berry Head Pond (GMNP) 19Jul00♀♂; Rocky Harbour (Bottom Brook bog) 6Aug98♂; Main River west 22Jul00♂.

Theridion differens Emerton, 1882
Nearctic. Mixed coniferous woods; wetlands.
Gander 20Jul78♀ (CNC); South Branch (Codroy) 24- 31Jul 74♂ (CNC); St. Georges 1Jul87♀ (CNC).

Theridion glaucescens Becker, 1879 [H]
Nearctic. Mixed coniferous woods; wetlands.
Woody Point 17Jul49♀ (FMNH?); Gambo 25Aug49♀ (FMNH?). This species not found by CDD in Hackman's collections in FMNH. This record may be erroneous but is retained here pending clarification.

Theridion montanum Emerton, 1882 [H]
Holarctic. Mixed coniferous woods.
Berry Head Pond (GMNP) 24Jul99♂; Gadds Harbour 24Jul99♀; Mt. Scio 15Sep99♀; Shallow Bay 13Jul97♂.

Theridion murarium Emerton, 1882 [H]
Nearctic. Mixed coniferous woods; wetlands.
Square Pond (which one unspecified) 9Jun81♂ (CNC). All Hackman's specimens immature.

Theridion petraeum L. Koch, 1872
Holarctic. Among stones at mid and high elevations on the Long Range Mountains.
Tablelands 1Aug00♀♀.

Theridion pictum (Walckenaer, 1802)
Holarctic. Mixed coniferous woods.
Gander 00Aug98♂; Main River west 28Jul00♂.

Theridula emertoni Levi, 1954 [H; *Theridula sphaerula* Emerton, 1882]
Nearctic. Mixed coniferous woods.
Gander 00Aug98♂; Lomond 14Jul98♀.

Thymoites oleatus (L. Koch, 1879)
Holarctic. Exposed coastal *Empetrum* barrens.
Savage Cove 23Aug98♀.

THERIDIOSOMATIDAE (1 sp.)
Theridiosoma gemmosum (L. Koch, 1877) [H; *Theridiosoma radiosum* (Emerton, 1884)]
Palaearctic; introduced. Mixed coniferous woods; wetlands.
Bay d'Espoir 15Jul85♀ (CNC); South Branch (Codroy) 3Jul49♀♀ (FMNH); Spruce Brook 8-9Jul49♀ (FMNH).

THOMISIDAE (14 spp.)
Bassaniana utahensis (Gertsch, 1932). [H; *Coriarachne versicolor* Keyserling, 1880]
Nearctic. Mixed coniferous woods; shrubs and herbs in clearings.
Gander 1Jul78♂; Terra Nova village 15Sep00♀.

Misumena vatia (Clerck, 1758) [H]
Holarctic. On flowers among shrubs and herbs; on flowers along roadsides.
Badger 27Jun80♀; Bakers Brook estuary 26Aug98♀; Blackhead (St. John's) 18Sep03♀; Gander 1Jul79♂; Hawkes Bay 1Jul98♂.

Ozyptila distans Dondale & Redner, 1975 [H; *Oxyptila americana* Banks, 1895]
Nearctic. Mixed coniferous woods.
Gander 00Aug98♂; TNNP 11Jun93♀♂.

Ozyptila gertschi Kurata, 1944
Holarctic. Coastal *Empetrum* barrens.
Burnt Cape 00Aug03♀♀♂♂.

Ozyptila sincera canadensis Dondale & Redner, 1975 [H; *Ozyptila bryantae* Gertsch, 1939]
Nearctic. Coastal rocky barrens.
Burnt Cape 00Aug03♀♀♂♂; Point Riche 13Jul99♀♂; Port au Choix 5Jul04♀.

Xysticus canadensis Gertsch, 1934 [H]
Holarctic. Mixed coniferous woods.
Crooked Lake 19Aug84♀ (CNC); Hampden 14Jun77♀ (CNC); Kings Point 19Aug84♀ (CNC); Main River 16Aug84♀ (CNC); 20 km north of Millertown 19Aug84♂ (CNC).

Xysticus discursans Keyserling, 1880 [H]
Nearctic. Mixed coniferous woods.
Gander 1Jul78♂; Lomond 9Jun94♂; Main River west 00Jul 98♂; Port au Choix 24Jul00♂.

Xysticus elegans Keyserling, 1880 [H]
Nearctic. Mixed coniferous woods; shrubs and herbs.
Corner Brook 16Aug49♀ (FMNH); Gambo 28Aug49♂ (FMNH).

Xysticus emertoni Keyserling, 1880 [H]
Holarctic. Rocky barrens; back of beaches.
Green Gardens 27Jun95♀; Highlands of St. John 14Aug00♀; New Ferolle 13Jul04♂; Point Riche 12Jul99♀; Western Brook estuary 29Jul97♀♀.

Xysticus keyserlingi Bryant, 1930
Nearctic. Exposed coastal *Empetrum* barrens; tops of Long Range Mountains.
Burnt Cape 00Aug03♀♂; Killdevil Mountain 17Aug99♂; Point Riche 4Aug00♀.

Xysticus labradorensis Keyserling, 1887
Holarctic. Exposed coastal *Empetrum* barrens.
Point Riche 18Aug02♀♂.

Xysticus luctuosus (Blackwall, 1836)
Holarctic. Mixed coniferous woods; shrubs and herbs.
Barbace Cove 7Jul03♂; Main River west 00Jul98♂; Seal Cove (Bonne Bay) 14Jul98♀♂.

Xysticus obscurus Collett, 1877
Holarctic. Exposed, rocky, coastal barrens; back of beaches.
Big Brook 19-21Jun02♀♂.

Xysticus triguttatus Keyserling, 1880 [H]
Nearctic. *Empetrum* barrens; abandoned meadows.
Big Brook 25Jun02♂; Blackhead (St. John's) 9Jul01♂; Eddies Cove East 21Jun00♀♂; Logy Bay 11Jul02♀♂; Point Riche 8Jul00♂.

ULOBORIDAE (1 sp.)
Hyptiotes gertschi Chamberlin & Ivie, 1935
Nearctic. Mixed coniferous woods.
Deer Arm 8Aug97♂; Berry Head Pond (GMNP) 14Aug98♂.

Discussion

Origins of the Newfoundland spider fauna

For present purposes we call all unidentified Newfoundland species Nearctic because the taxonomy of European and Holarctic spiders is relatively well known. The majority (c. 61%) of Newfoundland species are Nearctic, with significant Holarctic (c. 33%) and introduced (c. 6%) components (Table 1). Given that recruitment to Newfoundland would largely have been from the west on the prevailing winds (see above), the Nearctic proportion is not surprising. In Canada in general, the proportion of Holarctic species appears to increase with increasing latitude. The wetlands of Quebec, for example, had an overall Holarctic proportion of about 33%, while in the northern wetlands of the subarctic and arctic parts of northern Quebec the Holarctic component was nearly 50% (Koponen 1994). On the Belcher Islands (Hudson Bay) the Holarctic proportion was 58% (Koponen 1992).

Introduced species

The number and proportion of introduced Palaearctic species from several different arthropod taxa reflect Newfoundland's long history of European immigration and commerce, but the percentage varies between taxa. For example, the Plecoptera (stoneflies) and Ephemeroptera (mayflies) have no introduced species (Larson and Colbo 1983), approximately 17% (20 of 120) of the Cicadellidae (leafhoppers) are introduced (Hamilton and Langor 1987), and all 12 terrestrial Isopoda (wood-lice) were introduced to Newfoundland (Palmen 1951).

TABLE 1. Origins and composition of the spider fauna of Newfoundland.

Family	Nearctic	Holarctic	Introduced	Total species	% of total
Agelenidae	1	0	3	4	1.1
Amaurobiidae	5	0	0	5	1.4
Araneidae	7	10	3	20	5.5
Clubionidae	8	6	0	14	3.9
Cybaeidae	1	0	0	1	<1
Dictynidae	6	3	0	9	2.5
Gnaphosidae	3	11	0	14	3.9
Hahniidae	5	1	0	6	1.7
Linyphiidae	132	53	6	191	52.6
Liocranidae	0	1	0	1	<1
Lycosidae	15	9	0	24	6.6
Mimetidae	1	0	0	1	<1
Nesticidae	0	0	1	1	<1
Philodromidae	3	4	0	7	1.9
Pholcidae	0	0	1	1	<1
Pisauridae	1	0	0	1	<1
Salticidae	10	4	1	15	4.1
Tetragnathidae	5	1	0	6	1.7
Theridiidae	12	9	5	26	7.1
Theridiosomatidae	0	0	1	1	<1
Thomisidae	7	7	0	14	3.9
Uloboridae	1	0	0	1	<1
Totals: 22 Families	223 (61.4%)	119 (32.8%)	21 (5.8%)	363	

TABLE 2. The 21 spider species introduced to Newfoundland.

Agelenidae
- *Tegenaria atrica*
- *Tegenaria domestica*
- *Tegenaria duellica*

Araneidae
- *Araneus diadematus*
- *Larinioides sclopetarius*
- *Zygiella atrica*

Linyphiidae
- *Centromerita bicolor*
- *Dicymbium nigrum*
- *Erigone dentipalpis*
- *Lepthyphantes leprosus*
- *Lepthyphantes tenuis*
- *Tiso vagans*
- *Eidmanella pallida*

Pholcidae
- *Pholcus phalangioides*

Salticidae
- *Salticus scenicus*

Theridiidae
- *Achaearanea tabulata*
- *Achaearanea tepidariorum*
- *Enoplognatha ovata*
- *Neottiura bimaculata*
- *Steatoda bipunctata*

Theridiosomatidae
- *Theridiosoma gemmosum*

Twenty-one spider species are here considered to be introductions to Newfoundland (Table 2). Two species are widespread and locally abundant throughout the island: *Araneus diadematus* and *Tegenaria domestica* occur from the Avalon Peninsula in the south to the tip of the Northern Peninsula. Interestingly, neither of these now widespread species was seen by Hackman (1954) who only included *A. diadematus* in his list on the basis of a mention in Wiehle (1931). In fact the first North American record for this species was from Brigus, Newfoundland (Pickard-Cambridge 1881). Since both species are large and not easily overlooked, both were probably very rare prior to 1954 and have become widespread in the last 50 years. A similar, rapid colonisation has been demonstrated for other arthropod taxa. For example, in 1955 the carabid beetles *Amara aulica* Panzer and *Pterostichus melanarius* Illiger were respectively confined to the west coast of Newfoundland and known only from a single known locality on the Avalon Peninsula. In less than 30 years both species became widespread across Newfoundland (Larson and Langor 1982).

Other species are well established in Newfoundland but less widespread. *Steatoda bipunctata* has not been found north of Port au Choix. Neither *Larinioides sclopetarius* nor *Salticus scenicus* have been found north of Rocky Harbour. *Zygiella atrica* is particularly frequent on the Avalon Peninsula but has been found nowhere else in Newfoundland except Deer Lake. Whether these distributions are artefacts of collecting, intermediate points in the spread of these species across the island, or the limits of these species' colonising ability is unknown.

Dicymbium nigrum is well established as several wild populations but only in a restricted area in and around St. John's. A few species are known only from

TABLE 3. Comparison of seven Canadian provincial and territorial spider faunas.

	BC[1]	QC[2]	SK[3]	AB[3]	MB[4]	NF	YK[5]
Area 1000 km2 [6]	947.8	1700	651.9	661.19	649.95	111.39	483.45
Ecodistricts[7]	112	87	154	146	94	25	78
Latitude range°N [6]	49-60	45-62	49-60	49-60	49-60	47-52	60-69
Total species	*657*	*617*	*550*	*527*	*483*	*363*	*297*
Total families	*35*	*28*	*23*	*22*	*20*	*22*	*15*
Agelenidae	9	4	9	8	8	4	1
Amaurobiidae	10	14	4	5	7	5	2
Antrodiaetidae	2	0	0	0	0	0	0
Anyphaenidae	2	0	1	1	0	0	0
Araneidae	33	31	26	29	27	20	16
Clubionidae	15	21	17	19	20	14	7
Corinnidae	5	3	3	2	0	0	0
Cybaeidae	11	1	0	0	1	1	0
Dictynidae	29	23	30	19	21	9	10
Dipluridae	1	0	0	0	0	0	0
Dysderidae	1	1	0	0	0	0	0
Gnaphosidae	49	34	46	52	31	14	23
Hahniidae	15	5	6	7	5	6	4
Linyphiidae	231	240	198	201	179	191	136
Liocranidae	5	8	5	5	6	1	1
Lycosidae	47	53	41	46	40	24	30
Mecicobothriidae	1	0	0	0	0	0	0
Mimetidae	2	5	1	1	2	1	0
Miturgidae	1	1	0	0	0	0	0
Mysmenidae	1	0	0	0	0	0	0
Nesticidae	1	2	0	0	0	1	0
Oecobiidae	0	1	0	0	0	0	0
Oxyopidae	1	1	1	0	1	0	0
Philodromidae	33	20	24	22	22	7	13
Pholcidae	3	1	1	1	0	1	0
Pimoidae	2	0	0	0	0	0	0
Pisauridae	1	5	2	2	4	1	1
Salticidae	45	43	50	35	33	15	17
Segestriidae	1	0	0	0	0	0	0
Telemidae	1	0	0	0	0	0	0
Tetragnathidae	12	15	12	8	13	6	3
Theridiidae	51	48	38	27	31	26	14
Theridiosomatidae	0	1	0	0	0	1	0
Thomisidae	32	32	32	34	29	14	17
Titanoecidae	2	1	2	2	2	0	2
Uloboridae	1	3	1	1	1	1	0
Zoridae	1	0	0	0	0	0	0

[1]Bennett 2001; Bennett et al. 2004*. [2]Bélanger and Hutchinson 1992, as revised by Paquin et al. 2001, with additions in Paquin and Dupérré 2003. [3]Buckle and Holmberg 2004*. [4]Aitchison-Benell and Dondale 1990. [5]Dondale et al. 1997. Some familial placements adjusted in accordance with Platnick 2005*.

[6]Government Websites: Alberta, British Columbia, Manitoba, Newfoundland and Labrador, Quebec, Saskatchewan, Yukon 2004* (Some numbers approximate)

[7] Ecological Stratification Working Group 1995.

one or two specific buildings in the St. John's area, either houses and other domestic structures (*Pholcus phalangioides*, *Tegenaria duellica*, *Achaearanea tepidariorum* and *A. tabulata*) or commercial buildings (*Tegenaria atrica*). The remaining species are known from small numbers of specimens from a small number of localities in the wild; little can be said about them until further collections tell us more about their distributions and habitats.

Composition of the fauna: comparisons with other areas

In general terms the composition of any terrestrial fauna will be a reflection of land area, ecological diversity and latitudinal position. Table 3 compares these

TABLE 4. Proportions of Linyphiidae, Linyphiidae plus Lycosidae, and Linyphiidae plus Lycosidae plus Dictynidae in some northern spider faunas.

	BC[1]	QC[2]	SK[3]	AB[3]	MB[4]	NF	YK[5]	GL[6]	BL[7]	HZ[8]	PL[9]
Total families	35	28	23	22	20	22	15	10	8	4	3
Total species	657	617	550	527	483	363	297	70	33	13	7
Linyphiidae %	35.2	38.9	36.0	38.1	37.1	52.6	45.8	64.3	69.7	69	57.2
†L + L %	42.3	47.5	43.5	46.9	45.3	59.2	55.9	75.7	81.8	84	85.7
‡L + L + D%	46.7	51.2	48.9	50.5	49.7	61.7	59.3	78.6	84.9	92.3	100

[1]Bennett 2001; Bennett et al. 2004*. [2] Bélanger and Hutchinson 1992, as revised by Paquin et al. 2001, with additions in Paquin and Dupérré 2003. [3]Buckle and Holmberg 2004*. [4]Aitchison-Benell and Dondale 1990. [5]Dondale et al. 1997. [6]Larsen and Scharff 2003. [7]Koponen 1992. [8]Leech 1966. [9]Braendegaard 1960. Some familial placements adjusted in accordance with Platnick 2005.

†L+ L % = % of Linyphiidae + Lycosidae

‡L + L + D% = % of Linyphiidae + Lycosidae + Dictynidae

three geographical attributes, total number of species, number of families and number of species within each family for each of the seven Canadian provinces or territories for which there is information. Locality columns are arranged left to right in order of most to least total species. There is a general correlation between the three geographical attributes and the number of families and species; analysis of the obvious exceptions will not be possible until knowledge of the faunas is standardised.

Several authors (e.g. Leech 1966; Koponen 1992, 1996; Larsen and Scharff 2003) have pointed out that northern spider faunas are numerically dominated by species of Linyphiidae, Lycosidae and Dictynidae in descending order of importance. For example, species of these three families make up 100% of the most northern spider fauna in the world on Peary Land, Greenland (c. 82.5°N), excluding for present purposes the introduced agelenid *Tegenaria domestica* (Braendegaard 1960). Table 4 compares the cumulative proportions of these three families (i.e. Linyphiidae alone, Linyphiidae plus Lycosidae, Linyphiidae plus Lycosidae plus Dictynidae) as a scale of northernness for the seven Canadian areas considered in Table 3. In addition Table 4 includes the proportions in two other Canadian locations, the Belcher Islands (56° N) and Hazen Camp (82° N), and two non-Canadian locations, Peary Land (82.5° N) and the whole of Greenland (60°-82.5° N). The overall trend of increasing numerical dominance of Linyphiidae, Lycosidae and Dictynidae is confirmed.

Other Canadian spider fauna surveys have included species likely to be discovered in the area in question in the future (e. g. Dondale et al. 1997; Bélanger and Hutchinson 1992). While this may be justified when species absent from the area in question have been reported from a contiguous land mass, it seems less useful when dealing with an island.

Acknowledgments

We thank Lloyd Hollett and Kevin Pardy who donated many Newfoundland spiders to the CNC. We are grateful for access to the valuable collections made by Phil Taylor and his team (Acadia University), for the collections made by Anne-Marie Hynes and Shelley Pardy, and for the funding for the latter collections provided by the Newfoundland Inland Fish & Wildlife Division. We thank Parks Canada for permission to collect in Gros Morne National Park over several years. We are grateful to Dave Larson for providing access to his arthropod collections. We would also like to acknowledge all other collectors, too numerous to mention individually, who have contributed Newfoundland specimens directly or indirectly to the CNC. We are grateful to Robb Bennett, Don Buckle and Robert Holmberg for permission to use unpublished data. We thank Jim Redner for his many hours of labour on Newfoundland specimens. We want to thank the Biology Department, Memorial University, for facilities and supplies. JRP thanks Dave Larson for his encouragement and advice.

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Received 21 June 2004
Accepted 1 June 2005

Additions and Range Extensions to the Vascular Plant Flora of the Continental Northwest Territories and Nunavut, Canada III

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Cody, William J,. and Kenneth L. Reading. 2005. Additions and range extensions to the vascular plant flora of the continental Northwest Territories and Nunavut, Canada III. Canadian Field-Naturalist 119(2): 276-290.

Fifteen native taxa are reported as new to either District of Keewatin (now Nunavut in part) or District of Mackenzie (Nunavut contains the northeastern portion): *Aster puniceus*, *Astragalus eucosmus*, *Astragalus eucosmus* f. *albinus*, *Carex media*, *Epilobium latifolium* f. *albiflorum*, *Eriophorum viridi-carinatum*, *Erysiumum pallasii*, *Moneses uniflora*, *Najas flexilis*, *Potamogeton obtusifolius*, *Salix arctica* × *glauca*, *Salix glauca* ssp. *callicarpae*, *Salix myrtillifolia*, *Salix rotundifolia*, *Shepherdia canadensis*, taxa are new to Northwest Territories overall. Significant range extensions for 157 native taxa are included.

Key Words: Vascular plants, Mackenzie, Keewatin, Nunavut, flora, new records, range extensions, phytogeography.

Since the publication of *Additions and Range Extensions to the Vascular Plant Flora of the Continental Northwest Territories and Nunavut, Canada II* (Cody et al. 2003) a large number of specimens collected by Kenneth L. Reading in the Continental Northwest Territories between the years of 1978 and 1995 were discovered and forwarded to the senior author for examination. Many of these proved to be significant records and are reported here along with some additional specimens collected by D. Bush, D. Campbell, B. Cornish, V. J. Kajima, L. Kershaw, J. B. Korol, J. Lancaster, J. V. Matthews, J. W. Thieret, R. J. Reich, and J. Thompson.

All of these specimens are preserved in the Agriculture and Agri-Food Canada Herbarium (DAO). As in Cody et al (2003) the authors have continued to use the historic names "District of Keewatin" and "District of Mackenzie" to follow the format of Porsild and Cody (1980) *Vascular Plants of Continental Northwest Territories* and subsequent publications. However, continental "Keewatin" and the former northeastern portion of "District of Mackenzie" are now part of the recently defined Continental Nunavut Territory.

As in paper II a synopsis of the taxa addressed in the body of this paper follows with species listed in alphabetical order within categories. The taxa are then discussed in an annotated list by family in the same order as presented in the *Flora of the Continental Northwest Territories* (Cody and Porsild 1980) together with citation of specimens and other pertinent information.

New Taxa to the Continental Northwest Territories Status

New Taxa to the Continental Northwest Territories (Keewatin): (10)

Astragalus eucosmus
Astragalus eucosmus f. *albinus*
Carex media
Epilobium latifolium f. *albiflorum*
Eriophorum viridi-carinatum
Erysimum pallasii
Moneses uniflora
Salix glauca ssp. *callicarpaea*
Salix myrtillifolia
Shepherdia canadensis

New Taxa to the Continental Northwest Territories (Mackenzie): (5)

Aster puniceus
Potamogeton obtusifolius
Najas flexilis
Salix arctica X glauca
Salix rotundifolia

Range Extensions of Native Taxa in the Continental Northwest Territories (Keewatin): (48)

Anemone parviflora
Anemone richardsonii
Antennaria isolepis
Caltha natans
Campanula uniflora
Cardamine bellidifolia
Cardamine pratensis
Carex canescens
Carex rariflora
Carex rotundata
Carex scirpoidea
Cystopteris fragilis
Draba fladnizensis
Draba nivalis
Draba wahlenbergii
Dryopteris fragrans
Epilobium davuricum
Equisetum palustre
Festuca brachyphylla
Galium trifidum
Juncus arcticus
Juncus castaneus ssp. *castaneus*
Ledum groenlandicum
Minuartia biflora
Minuartia rossii

Minuartia rubella
Polygonum viviparum
Potentilla nivea ssp. *nivea*
Potentilla palustris
Pyrola secunda
Ranunculus sabinei
Ranunculus × *spitzbergensis*
Rubus arcticus ssp. *acaulis*
Rubus idaeus
Sagina caespitosa
Salix arctophila
Salix fuscescens
Salix planifolia
Salix reticulata
Salix richardsonii
Saxifraga nelsoniana ssp. *porsildiana*
Saxifraga rivularis
Scirpus caespitosus ssp. *austriacus*
Silene walensis
Stellaria calycantha
Stellaria longipes
Tofieldea coccinea
Tofieldia pusilla

Range Extensions of Native Taxa in the Continental Northwest Territories (Mackenzie): (109)

Alisma triviale
Anemone parviflora
Arctostaphylos alpina
Arnica angustifolia ssp. *attenuata*
Arnica chamissonis
Artemisia furcata
Artemisia tilesii
Aster pygmaeus
Aster sibiricus
Astragalus australis
Braya glabella
Braya humilis
Calamagrostis lapponica
Calamagrostis purpurascens
Calamagrostis stricta ssp. *stricta*
Callitriche hermaphroditica
Caltha palustris var. *arctica*
Cardamine bellidifolia
Carex bebbii
Carex nardina
Carex scirpoidea
Carex subspathacea
Carex supina ssp. *spaniocarpa*
Carex vaginata
Cerastium alpinum
Cerastium beeringianum
Chenopodium dessicatum
Chrysosplenium tetrandrum
Crepis nana
Cryptogramma crispa var. *acrostichoides*
Cystopteris fragilis
Cystopteris montana
Danthonia spicata
Descurainia sophioides
Draba juvenalis
Draba wahlenbergii
Dryopteris fragrans
Elymus canadensis
Elymus macrourus
Elymus trachycaulus ssp. *violaceus*
Epilobium palustre
Equisetum palustre
Erigeron uniflorus ssp. *eriocephalus*
Eriophorum angustifolium
Eriophorum callitrix
Eriophorum triste
Eriophorum vaginatum
Erysimum pallasii
Eutrema edwardsii
Festuca richardsonii
Gentiana affinis
Hedysarum alpinum
Hedysarum boreale ssp. *mackenzii*
Hierochloe hirta ssp. *arctica*
Juncus arcticus
Juncus castaneus ssp. *castaneus*
Juncus stygius ssp. *americanus*
Juncus triglumis ssp. *albescens*
Juniperus communis
Lagotis glauca
Limosella aquatica
Linnaea borealis var. *americana*
Lupinus arcticus
Luzula wahlenbergii
Lycopodium selago
Lycopus uniflorus
Matricaria ambigua
Minuartia yukonensis
Muhlenbergia glomerata
Myriophyllum alterniflorum
Nymphaea tetragona ssp. *leibergii*
Oxytropis arctobia
Oxytropis deflexa ssp. *foliosa*
Oxytropis maydelliana
Papaver radicatum
Parrya arctica
Pedicularis capitata
Pedicularis langsdorfii ssp. *arctica*
Pedicularis lapponica
Pedicularis macrodonta
Phragmites australis
Poa alpina
Poa glauca
Poa pratensis ssp. *alpigena*
Potamogeton filiformis
Potamogeton foliosus
Potentilla biflora
Ranunculus aquatilis var. *eradicatus*
Rosa blanda
Rhynchospora alba
Salix alaxensis
Salix arctica
Salix glauca var. *acutifolia*
Salix planifolia
Salix reticulata
Salix richardsonii
Salix sphenophylla
Saxifraga nivalis
Scirpus rollandii
Senecio congestus
Silene walensis
Solidago graminifolia var. *major*
Sparganium hyperboreum
Spartina gracilis

Stellaria longipes
Triglochin maritimum
Trisetum spicatum
Vaccinium vitis-idaea var. *minus*
Woodsia ilvensis

Annotated List

LYCOPODIACEAE

Lycopodium selago L., Mountain Club-moss – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Windy Lake, 68°03'15"N 106°37'00"W, *K. Reading 152*, 14 July 1987 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 175 kilometers north of a site adjacent to the Arctic Circle (Porsild and Cody 1980).

EQUISETACEAE

Equisetum palustre L., Marsh Horsetail – MACKENZIE: muddy tundra pond margin, Coppermine River Area, 67°31'15"N 116°01'00"W, *K. Reading 8*, 31 Aug. 2002 (DAO); rocky fen pools, Coppermine River Area, 67°33'30"N 116°14'54"W, *K. Reading 47*, 21 Aug. 2002 (DAO); muddy flooded rock polygon, Coppermine River Area, 67°34'00"N 116°17'00"W, *K. Reading 9*, 1 Sept. 2002 (DAO); Hope Bay Area, northeast of Bathurst Inlet, Windy Lake, 68°03'15"N 106°37'00"W. *K. Reading 204*, 16 July 1987 (DAO); KEEWATIN: SY Area, 62°12'20"N 97°52'00"W, *K. Reading 121*, 17 Aug. 1984 (DAO).

The first four specimens cited above extend the known range of this species about 500 kilometers northeast of the east end of Great Bear Lake (Porsild and Cody 1980). The fifth specimen is about 170 kilometers south of the only previously known localities in central KEEWATIN (Cody et al. 2003).

PTERIDACEAE

Cryptogramma crispa (L.) R.Br. var. *achrostichoides* (R.Br.) C.B. Clarke, Mountain-parsley – MACKENZIE: common on outcrop, 63°00'00"N 109°55'00"W, *K. Reading 426*, 8 Aug. 1995 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 85 kilometers northeast of the east end of Great Slave Lake (Porsild and Cody 1980).

ASPIDIACEAE

Cystopteris fragilis (L.) Bernh., Fragile Fern – MACKENZIE: 63°00'00"N 109°55'00"W, *K. Reading 423*, 11 Aug. 1995 (DAO); KEEWATIN: Griffin Lake, 61°17'20"N 98°42'00"W, *K. Reading 98*, 19 Aug. 1990 (DAO).

The first specimen cited above is an extension of the known range in the Territory of about 70 kilometers northeast of the east end of Great Slave Lake and the second specimen is the southernmost yet known in the District of Keewatin (Porsild and Cody 1980).

Cystopteris montana (Lam.) Bernh., Mountain Bladder Fern – MACKENZIE: uncommon under tamaracks, 63°00'00"N 109°52'00"W, *K. Reading 429*, 9 Aug. 1995 (DAO).

This is a rare species in the Continental Northwest Territories which Porsild and Cody (1980) knew from only three localities west of the west end of Great Slave Lake. The specimen cited above is an extension of the range to the east of Great Slave Lake of about 390 kilometers.

Dryopteris fragrans (L.) Schott, Fragrant Cliff Fern – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 231*, 11 Aug. 1987 (DAO); KEEWATIN: south southwest of Bissett Lake, 63°44'00"N 95°30'00"W, *K. Reading 336*, 28 Aug. 1982 (DAO).

This is a widespread species in Canada. The first specimen cited above is an extension of the known range of about 180 kilometers north northwest from the Arctic Circle and the second specimen is from a site between two sites south of the Arctic Circle (Porsild and Cody 1980).

Woodsia ilvensis (L.) R.Br., Rusty Woodsia – MACKENZIE: 63°00'00"N 109°55'00" W, *K. Reading 425*, 8 Aug. 1995 (DAO); outcrop beside bog, 62°59'00"N 109°51'00"W, *K. Reading 428*, 9 Aug. 1995 (DAO); Hope Bay area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 116°33'00"W, *K. Reading 213*, 11 Aug. 1987 (DAO).

The first two specimens cited above are an extension of the known range in the Territory (Porsild and Cody 1980) of about 170 kilometers northeast of a site near the east end of Great Slave Lake. The second specimen is a northward extension of about 75 kilometers from a site reported by Cody et al. (1984).

CUPRESSACEAE

Juniperus communis L. s.l., Ground Juniper – MACKENZIE: dolomite scarp, Coppermine River Area, 67°09'00"N 115°45'00"W, *K. Reading 83*, 28 Aug. 2002 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 170 kilometers northeast of a site at the east end of Great Bear Lake (Porsild and Cody 1980).

SPARGANIACEAE

Sparganium hyperboreum Laest. – MACKENZIE: big pool in creek, Coppermine River Area, 67°31'10"N 116°10'05"W, *K. Reading 52*, 22 Aug. 2002 (DAO).

The specimen cited above is from a site midway between a site north of the east end of Great Bear Lake and the south end of Bathurst Inlet (Porsild and Cody 1980). This species was only found once in this area.

POTAMOGETONACEAE

Potamogeton filiformis Pers., Fine-leaved Pondweed – MACKENZIE: sandy Lake, Coppermine River Area, 67°06'05"N 115°44'50"W, *K. Reading 50*, 21 Aug. 2002 (DAO).

The specimen cited above is from a site midway between a site north of the east end of Great Bear Lake and Bathurst Inlet (Porsild and Cody 1980).

Potamogeton foliosus Raf. (P. foliosus Raf. var. macellus Fern.), Closed-leaved Pondweed – MACKENZIE: 61.7382°N 121.1534°W, *L. Kershaw 18*, 2003 (DAO).

This species was considered rare in the Northwest Territories by McJannet et al. (1995), who knew it only from the vicinities of Yellowknife, Nahanni National Park and the Great Bear River areas. The specimen cited above is from a site in the Keller Lake area east of the Mackenzie River.

Potamogeton obtusifolius M.&K., Blunt-leaved Pondweed – MACKENZIE: Mackenzie River-Yellowknife Highway, small lake at Mile 12.7 S, *Thieret & Reich 8358*, 28 July 1961 (DAO); same area, small lake, Mile 38.3 S, *Thieret & Reich 4947*, 23 July 1961 (DAO); 62.158°N 122.4891°W, *L. Kershaw 19*, 2003 (DAO).

Porsild and Cody (1980) suggested that this species was to be expected in the southern parts of the Precambrian Shield area. Haynes (1974) reported it from the vicinity of Yellowknife. Haynes had already revised the first three specimens in 1971, but this revision was overlooked by Porsild and Cody. In 1995 he confirmed his identification. The fourth specimen cited above from a site near the Mackenzie River is an extension of the known range in the Territory of about 400 kilometers to the west.

NAJADACEAE

Najas flexilis (Willd.) Rostk. & Schmidt, Wavy Water Nymph – MACKENZIE: beside beaver lodge near northwest corner of unnamed lake, 62.9854°N 123.1753°W, *L. Kershaw 14*, 2003 (DAO).

The specimen cited above is new to the flora of the Continental Northwest Territories (Porsild and Cody 1980).

SCHEUCHZERIACEAE

Triglochin maritimum L., Seaside Arrow-grass – MACKENZIE: wet fen, Coppermine River Area, 67°34'10"N 116°18'50"W, *K. Reading 153*, 1 Sept. 2002 (DAO).

The specimen cited above is from a location midway between a site at the northeast end of Great Bear Lake and a site near the south end of Bathurst Inlet (Porsild and Cody 1980).

ALISMATACEAE

Alisma triviale Pursh (*A. plantago-aquatica* L. var. *americanum* J. A. Schultes) – MACKENZIE: Willowlake River, 62.7024°N 123.1043°W, sand and gravel bar on the north side of the river, *D. Soppet 2*, 2003 (DAO).

This species was considered rare in the Territory on the basis of a single collection from the shoreline of Hanging Ice River, north of Fort Smith (McJannet et al. 1995). The specimen cited above is an extension of the known range in the Territory of about 500 kilometers to the northwest.

POACEAE

Calamagrostis lapponica (Wahlenb.) Hartm. – MACKENZIE: Camp Peninsula on September (Mouse) Lake, Coppermine River Area, 67°06'05"N 115°44'50"W, *K. Reading 115*, 24 Aug. 2002 (DAO).

The specimen cited above is from a site midway between the east end of Great Bear Lake and the south end of Bathurst Inlet (Porsild and Cody 1980).

Calamagrostis purpurascens R.Br. – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Windy Lake, 68°03'15"N 106°37'00"W, *K. Reading 318*, 29 June 1987 (DAO).

The specimen cited above is from a site about 170 kilometers north of the south end of Bathurst Inlet and is the most northwestern yet known from the District of Mackenzie (Porsild and Cody 1980).

Calamagrostis stricta (Timm) Koeler ssp. *stricta* (*C. neglecta* (Ehrh.) Gaertn., Mey. & Scherb.) – MACKENZIE: "Lunch outcrop", Coppermine River Area, 67°32'15"N 116°02'30"W, *K. Reading 110*, 26 Aug. 2002 (DAO); Hope Bay Area, northeast of Bathurst Inlet, Windy Lake, 63°03'15"N 106°37'00"W, *K. Reading 304*, 15 July 1978 (DAO).

The first specimen cited above is from a site about 250 kilometers northeast of the east end of Great Bear Lake (Porsild and Cody 1980). To the north on Victoria Island it is known about 250 kilometers away, and to the east about 630 kilometers. The second specimen is from a site about 290 kilometers northeast of the first specimen location.

Danthonia spicata (L.) Beauv., Poverty Oatgrass – MACKENZIE: along break between the sandbar and the Black Spruce forest on the edge of the river, north side sandbar of A River between Two Mountains, 62.942°N 123.0399°W, *D. Soppet 6*, 2003 (DAO).

Porsild and Cody (1980) suggested that this species should be looked for along the southern rim of the Precambrian Shield east of the Slave River. Specimens which were all collected in Nahanni National Park and identified as *D. intermedia* have since been revised to *D. spicata*. The specimen cited above is from a site northeast of the park.

Elymus canadensis L., Canadian Wild Rye – MACKENZIE: upper shore of Mackenzie River about 100 m north of ferry landing, 62.1498°N 122.5327°W, *L. Kershaw 7*, 2003 (DAO).

This is a rare species in the Territory (McJannet et al. 1995). The specimen cited above is an extension of the known range of about 175 kilometers north of a site adjacent to the Liard River. It is however not far distant from a site on the Norman Wells Pipeline adjacent to the Willowlake River winter road which presumably was introduced (Cody et al. 2000).

Elymus macrourus (Turcz.) Tzvelev (*Agropyron sericeum* Hitchc.) – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Windy Lake, 68°03'15"N 106°37'00"W, *K. Reading 310*, 29 June 1987 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 750 kilometers east of sites adjacent to the Arctic Coast (Porsild and Cody 1980).

Elymus trachycaulus (Link) Gould ex Shinners ssp. *violaceus* (Hornem.) A. & D. Löve (*Agropyon trachycaulum* (Link) Malte sl.) – MACKENZIE: sand ridge, Coppermine River Area, 67°33'00"N 115°58'00"W, *K. Reading 97A*, 5 Sept. 2002 (DAO) (determined by S. Darbyshire 2002).

The specimen cited above is an extension of the known range of this group (Porsild and Cody 1980) of about 250 kilometers northeast of the east end of Great Bear Lake.

Festuca brachyphylla Schultes – KEEWATIN: Bray Lake, 61°26'N 97°59'W, *K. Reading 104*, 21 June 1990 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 150 kilometers to the northeast of a site in the extreme southwest of the Territory (Porsild and Cody 1980).

Festuca richardsonii Hook. (*F. rubra* L. ssp. *richardsonii* (Hook.) Hultén) – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Windy Lake, 68°03'15"N 106°37'00"W, *K. Reading 312B*, 29 June 1987 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 200 kilometers north of the south end of Bathurst Inlet (Porsild and Cody 1980).

Hierochloe hirta (Schrank) Borbas ssp. *arctica* (G.) Weim. (*H. odorata* pro parte sensu Porsild and Cody (1980), Sweet Grass – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Windy Bay, 68°03'15"N 106°37'00"W, *K. Reading 317*, 29 June 1987 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 540 kilometers northeast of the northeast end of Great Bear Lake (Porsild and Cody 1980).

Muhlenbergia glomerata (Willd.) Trin. – MACKENZIE: mineral spring, Mackenzie Valley pipeline survey, 61°37'17"N 121°30'14"W, *L. Kershaw s.n.*, 8 Aug. 2002 (DAO).

The specimen cited above which is the northernmost yet found in the Territory is an extension of the known range of about 300 kilometers to the northwest of a site adjacent to the Liard River mapped by Porsild and Cody (1980).

Phragmites australis (Cav.) Trin. ex Steud., (*P. communis* Trin. var. *berlandieri* (Fourn.) Fern.), Common Reed – MACKENZIE: shallow water about 10 m from the shore of a large alkaline lake, 61.7617°N 121.0793°W, *L. Kershaw 17*, 2003 (DAO).

The specimen cited above from the vicinity of Fort Simpson is from only the second known site in the Territory about 130 kilometers to the northeast in the vicinity of Yohin Lake (Scotter and Cody 1974).

Poa alpina L., Alpine Blue Grass – MACKENZIE: Coppermine River Area, Camp Peninsula on September (Mouse) Lake, 67°06'05"N 115°44'50"W, *K. Reading 118*, 24 Aug. 2002 (DAO); Hope Bay Area, northeast of Bathurst Inlet, Windy Lake, 68°03'15"N 106°37'00"W, *K. Reading 321*, 29 June 1987 (DAO).

The first specimen cited above extends the known range in the Territory about 125 kilometers west and the second specimen about 125 kilometers north of a site adjacent to Burnside Landing at latitude 66°51'N adjacent to Bathurst Inlet (Cody et al. 1984).

Poa glauca Vahl – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Windy Lake, 68°03'15"N 106°37'00"W, *K. Reading 313*, 29 June 1987 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 170 kilometers from the south end of Bathurst Inlet (Porsild and Cody 1980).

Poa pratensis L. ssp. *alpigena* (L.) Lindm. (*P. alpigena* (Fr.) Lindm.) – MACKENZIE: George Lake Camp, 65°53'10"N 107°23'00"W, *K. Reading 463, 467, 468, 469*, 16 Aug. 1988 (DAO); Hope Bay Area, northeast of Bathurst Inlet, Windy Lake, 68°03'05"N 106°37'00"W, *K. Reading 316, 319*, 29 June 1987 (DAO).

The first location cited above is about 85 kilometers south of sites near latitude 67°N reported by Cody et al. (1984). The Windy Lake sites are the northeasternmost yet known from the Territory and are about 130 kilometers north of latitude 67°N.

Spartina gracilis Trin., Alkali Cord Grass – MACKENZIE: sandbar on north side of river, Willowlake River, 62.7024°N 123.1043°W, *D. Soppet 28*, 2003 (DAO).

This is a rare species in the Territory (McJannet et al. 1995). The specimen cited above is an extension of the known range of about 240 kilometers northwest of the vicinity of Fort Simpson.

Trisetum spicatum (L.) Richt. – MACKENZIE: George Lake Camp, 65°53'10"N 107°23'8"W, *K. Reading 470*, 18 Aug. 1988 (DAO); Hope Bay Area, northeast of Bathurst Inlet, Windy Lake, 68°03'15"N 106°37'00"W, *K. Reading 306, 312A, 320, 322*, 29 June 1987 (DAO).

The first location cited above is about 85 kilometers south of sites near latitude 67°N reported by Cody et al. (1984). The Windy Lake site is the northeasternmost yet known from the Territory and is about 130 kilometers north of latitude 67°N.

CYPERACEAE

Carex bebbii Olney – MACKENZIE: Mackenzie River Valley pipeline survey, steep boulder strewn stream shore of Mackenzie River near Liard, 61°50'53"N 121°10'7"W, *L. Kershaw s.n.*, 8 Aug. 2002 (DAO).

Although widespread across much of Canada, Porsild and Cody (1980) knew this rare plant in the Territory from only four locations: near Fort Smith, Fort Good Hope, Fort Simpson and Fort Liard.

Carex canescens L. – KEEWATIN: Griffin Lake, 61°16'30"N 98°42'00"W, *K. Reading 100*, 26 July 1990 (DAO).

The specimen cited above is the northernmost yet found in the Territory and is from a site about 60 kilometers northeast of a site mapped by Porsild and Cody (1980).

Carex media R.Br. – KEEWATIN: Griffin Lake, 61°16'30"N 98°42'00"W, *K. Reading 99*, 26 July 1990 (DAO).

The specimen cited above is the first known from this Territory. It is from a site about 85 kilometers northeast of a site in the province of Manitoba, just south of latitude 60°N (Porsild and Cody 1980).

Carex nardina Fries – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Windy Lake, 68°03'15"N 106°37'00"W, *K. Reading 301*, 14 July 1987 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 170 kilometers northeast of a location cited by Cody et al. (1984) and is the northeasternmost yet known in the Territory.

Carex rariflora (Wahlenb.) Sm. – KEEWATIN: west of Imikula Lake, 62°10'00"N 97°40'20"W, *K. Reading 397*, 10 Aug. 1983 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 80 kilometers inland from sites adjacent to the Hudson Bay coast (Porsild and Cody 1980).

Carex rotundata Wahl. – KEEWATIN: SY area, 62°12'20"N 97°53'00"W, *K. Reading 219*, 19 July 1984 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 80 kilometers northeast of a site in the extreme south mapped by Porsild and Cody (1980).

Carex scirpoidea Michx. – MACKENZIE: sand flats, Coppermine River area, 67°06'05"N 115°44'50"W, *K. Reading 15A*, 8 Sept. 2002 (DAO); Hope Bay Area, northeast of Bathurst Inlet, Windy Lake, 68°03'15"N

106°37'00"W, *K. Reading 287*, 15 July 1987 (DAO); KEEWATIN: Griffin Lake, 61°16'30"N 98°42'00"W, *K. Reading 226*, 26 July 1990 (DAO).

The first specimen cited above is from a site midway between Coppermine and the south end of Bathurst Inlet (Porsild and Cody 1980). The second specimen is an extension of the known range in the Territory of about 170 kilometers northeast of the south end of Bathurst Inlet and is the northeasternmost yet known in the Territory. The third specimen is an extension of about 100 kilometers northeast of the southwesternmost previously known site in Keewatin (Porsild and Cody 1980).

Carex subspathacea Wormskj. – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Windy Lake, 68°03'15"N 106°37'00"W, *K. Reading 283*, 15 July 1987 (DAO).

The specimen cited above of this rare northern species is from a site about 170 kilometers northeast of the south end of Bathurst Inlet (Porsild and Cody 1980) and is the easternmost yet found in the Territory.

Carex supina Wahl. ssp. *spaniocarpa* (Steud.) Hultén – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Windy Lake, 68°03'15"N 106°37'00"W, *K. Reading 311*, 29 June 1987 (DAO).

The specimen cited above is from a site about 170 kilometers northeast of the south end of Bathurst Inlet (Porsild and Cody 1980) and is the northeasternmost yet found in the Territory.

Carex vaginata Tausch – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 330*, 4 Aug. 1987 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 150 kilometers northeast of a site near Burnside Landing adjacent to Bathurst Inlet (Cody et al. 1984).

Eriophorum angustifolium Honckn. – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Windy Lake, 68°03'15"N 106°37'00"W, *K. Reading 202*, 15 July 1987 (DAO); Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 261*, 1 Aug. 1987 (DAO).

The specimens cited above are a northern extension of the known range in the Territory of about 170 kilometers north of a site east of the south end of Bathurst Inlet (Porsild and Cody 1984).

Eriophorum callitrix Cham. – MACKENZIE: George Lake Camp, 65°53'12"N 107°23'8"W, *K. Reading 465*, 18 Aug. 1988 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 80 kilometers south of the south end of Bathurst Inlet (Porsild and Cody 1980).

Eriophorum triste (Th. Fr.) Hadac & Löve – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Windy Lake, 68°03'15"N 106°37'00"W, *K. Reading 286*, 5 July 1987 (DAO).

The specimen cited above of this circumpolar arctic-alpine species is an extension of the known range in the Territory of about 500 kilometers northeast of a site adjacent to the east end of Great Bear Lake. Adjacent to the Arctic Coast it is known about 400 kilometers to the west and it is also known from Victoria Island (Porsild and Cody 1980).

Eriophorum vaginatum L. – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Windy Lake, 68°03'15"N 106°37'00"W, *K. Reading 285*, 5 July 1987 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 150 kilometers northeast of sites adjacent to the middle of Bathurst Inlet (Cody et al. 1984).

Eriophorum viridi-carinatum (Engelm.) Fern. – KEEWATIN: SY area, 62°12'30"N 97°55'00"W, *K. Reading 252*, 17 Aug. 1984 (DAO).

This species is new to Continental District of Keewatin. It is known to the west in the District of Mackenzie about 625 kilometers away at the east end of Great Slave Lake and to the southwest in Saskatchewan about 475 kilometers away just south of the provincial border (Porsild and Cody 1980).

Rhynchospora alba (L.) Vahl, White Beak-rush – MACKENZIE: 61.9954°N 121.5027°W, *L. Kershaw 20*, 2003 (DAO).

This is a rare species in the Northwest Territories (McJannet et al. 1995) known from a single site near Hearst Lake (Cody and Talbot 1978) south of the east end of Great Slave Lake. The specimen cited above is from a site about 150 kilometers to the northwest.

Scirpus caespitosus L. ssp. *austriacus* (Pallas) Asch. & Graebn. – KEEWATIN: east of Pebble Beach Lake, south of Yathkyed Lake, 62°22'00"N 97°28'00"W, *K. Reading 178*, 10 July 1985 (DAO).

The specimen cited above is from a site midway between sites near the southern territories border and latitude 64°N (Porsild and Cody 1980).

Scirpus rollandii Fern. – MACKENZIE: Mackenzie River Valley pipeline survey, mineral rich site near springs, mud hummocks, 65°32'24"N 127°36'47"W, *L. Kershaw s.n.*, 1 Aug. 2002 (DAO); hundred plus plants in calcareous area where stream widens and pools on flat area before flowing into mineral lake, Wrigley area, 62.7307°N 123.1098°W, *D. Soppet 26A*, 2003 (DAO).

McJannet et al. (1995) knew this rare species in the Territory from only four localities, one near the northwest end of Great Slave Lake and three in the Mackenzie Mountains. The first specimen cited above is from a site northeast of the previously northernmost site in the mountains. The second specimen is from a site midway between the Mackenzie Mountain site and a site west of the north arm of Great Slave Lake.

JUNCACEAE

Juncus arcticus Willd. – MACKENZIE: Coppermine River Area, sandy lakeshore, 67°06'08"N 115°44'50"W, *K. Reading 15B*, 15 Aug. 2002 (DAO); KEEWATIN: Big Bird Lake, 62°17'30"N 97°38'00"W, *K. Reading 180*, 25 June 1985 (DAO).

The first specimen cited above is from a site about 100 kilometers west of Bathurst Inlet. The second specimen is from a site midway between a site adjacent to the Manitoba border west of Hudson Bay and a site about latitude 63°30'N east of longitude 100°W (Porsild and Cody 1980).

Juncus castaneus Smith ssp. *castaneus* – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 329*, 4 Aug. 1987 (DAO); KEEWATIN: No-camp Lake, south of Yathkeyed Lake, 62°22'00"N 97°27'30"W, *K. Reading 201*, 21 July 1985 (DAO); Big Bird Lake, 62°17'30"N 97°38'00"W, *K. Reading 181*, 25 June 1985 (DAO).

The first specimen cited above is an extension of the known range in the Territory of about 200 kilometers northeast of the south end of Bathurst Inlet. The second and third specimens are from sites about 125 kilometers north of a site in the interior of the District of Keewatin mapped by Porsild and Cody (1980).

Juncus stygius L. ssp. *americanus* (Buch.) Hultén, Bog Rush – MACKENZIE: Mackenzie River Valley pipeline survey, sandy shoreline of creek, 61°19'27"N 120°50'21"W, *L. Kershaw s.n.*, 3 Aug. 2002 (DAO); in graminoid/shrub fen in lower wet spots, 60.6383°N 120.3463°W, *D. Soppet 9*, 17 Aug. 2003 (DAO).

The first specimen cited above from south of Fort Simpson is only the fourth known in the Territory. McJannet et al. (1995) knew it from just north of latitude 60°N from south of the east and west ends of Great Slave Lake and adjacent to Hudson Bay.This species was first recorded in the Territory by J. W. Thieret (1959) on the basis of a specimen collected by Thieret and Reich (1964) from among sedges at foot of "hummock island" in marly lake at mile 44½ Enterprise-Mackenzie River Highway, about 215 kilometers east of the specimens cited above.

Juncus triglumis L. ssp. *albescens* (Lange) Hultén (*J. albescens* (Lange) Fern.) – MACKENZIE: Coppermine River Area, 67°06'05"N 115°44'50"W, *K. Reading 297*, 3 Sept. 2002 (DAO).

The specimen cited above is from a site midway between the south end of Bathurst Inlet and sites at the east end of Great Bear Lake (Porsild and Cody 1980).

Luzula wahlenbergii Rupr. – MACKENZIE: George Lake Camp, 65°55'10"N 107°23'00"W, *K. Reading 466*, 18 Aug. 1988 (DAO).

The specimen cited above is from a site about 175 kilometers west of a site at about 101°W longitude just south of latitude 66°N (Porsild and Cody 1980).

LILIACEAE

Tofieldia coccinea Richards. – KEEWATIN: Kazan Falls, 63°43'00"N 95°51'30"W, *K. Reading 348*, 30 Aug. 1982 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 150 kilometers east of specimens adjacent to longitude 100°W (Porsild and Cody 1980).

Tofieldia pusilla (Michx.) Pers. – KEEWATIN: south of Bissett Lake, 63°43'00"N 95°18'00"W, *K. Reading 347*, 22 July 1982 (DAO).

The specimen cited above is from a site about 150 kilometers east of a site just east of longitude 100°W (Porsild and Cody 1980).

SALICACEAE

Salix alaxensis (Anderss.) Cov. – MACKENZIE: sand flat below esker, Coppermine River Area, 67°33'00"N 115°58'00"W, *K. Reading 308*, 5 Sept. 2002 (DAO) (determined by G. Argus).

The specimen cited above is from a site midway between the south end of Bathurst Inlet and the vicinity of Coppermine (Porsild and Cody 1980).

Salix arctica Pallas, Arctic Willow – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Windy Lake, 68°03'15"N 106°37'00"W, *K. Reading 442*, 7 July 1987 (DAO); Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 278*, 24 June 1987, *250*, 4 Aug. 1987, *K. Reading 274*, 10 Aug. 1987 (DAO) (determined by G. Argus).

The four specimens cited above are a northeast extension of the known range in the Territory of about 170 kilometers from a site at the southern end of Bathurst Inlet (Porsild and Cody 1980).

Salix arctica × *glauca* – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Windy Lake, 68°03'15"N 106°37'00"W, *K. Reading 448, 449, 450,* 7 July 1987, 14 July 1987 (DAO) (determined by G. Argus).

This putative hybrid was not known to Porsild and Cody (1980).

Salix arctophila Cockerell – KEEWATIN: southwest of Big Bird Lake, south of Yathkyed Lake, 62°16'50"N 97°41'00"W, *K. Reading 144*, 28 June 1985 (DAO); southwest of Big Bird Lake, 62°17'00"N 97°40'00"W, *K. Reading 30*, 28 June 1985 (DAO); southwest of No-camp Lake, south of Yathkyed Lake, 62°22'40"N 97°27'30"W, *K. Reading 436*, 11 July 1985 (DAO); Camp 2, 61°21'00"N 97°53'30"W, *K. Reading 447*, 7 July 1990 (DAO) (determined by G. Argus).

The specimens cited above are from sites midway between the Hudson Bay Coast and a site just east of longitude 100°W (Porsild and Cody 1980).

Salix fuscescens Anderss. – KEEWATIN: Big Bird Lake, 62°18'00"N 97°39'00"W, *K. Reading 36*, 25 June 1985 (DAO); Washaneepisuki Lake, 62°12'30"N 97°52'00"W, *K. Reading 141*, 17 July 1984 (DAO); north of No-camp Lake, 62°22'15"N 97°27'10"W, *K. Reading 435*, 11 July 1985 (DAO) (determined by G. Argus).

The specimens cited above are from sites midway between the Hudson Bay Coast and a site just east of longitude 100°W (Porsild and Cody 1980).

Salix glauca L. var. *acutifolia* (Hook.) Schneid., Blue-green Willow – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 276*, 10 Aug. 1987 (DAO) (determined by G. Argus).

The specimen cited above is an extension of the known range in the Territory of about 170 kilometers northeast of the south end of Bathurst Inlet and is the northeasternmost site in the Territory (Porsild and Cody 1980).

Salix glauca L. ssp. *callicarpaea* (Trautv.) Böcher – KEEWATIN: Bray Lake, 61°26'N 97°59'W, *K. Reading 451*, 21 June 1990 (DAO); Washaneepisuki Lake, 62°12'30"N 97°52'00"W, *K. Reading 148*, 17 July 1984

(DAO); north of No-camp Lake, south of Yathkyed Lake, 62°22'15"N 97°28'10"W, *K. Reading 138*, 16 July 1985 (DAO); north of No-camp Lake south of Yathkyed Lake, 62°22'00"N 97°30'05"W, *K. Reading 139*, 22 July 1985 (DAO) (determined by G. Argus).

This subspecies was known in northeastern North America from Greenland, Labrador, Newfoundland and Quebec (specimens in DAO determined by G. Argus). The specimens cited above extend the known range into central southern District of Keewatin.

Salix myrtillifolia Anderss., Blueberry Willow – KEEWATIN: Bray Lake, 61°26'N 97°59'W, *K. Reading 444*, 21 June 1990 (DAO) (determined by G. Argus).

This species is new to mainland District of Keewatin. The nearest site mapped by Porsild and Cody (1980) was in northwestern Manitoba about 340 kilometers to the southwest and to the west in the District of Mackenzie it is common west of about longitude 106°W.

Salix planifolia Pursh, Tea-leaf Willow – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Windy Lake, 68°03'15"N 106°37'00"W, *K. Reading 446, 452*, 1 and 7 July 1987 (DAO); KEEWATIN: Washaneepisuki Lake, 62°12'30"N 97°52'00"W, *K. Reading 142*, 15 July 1984 (DAO); Big Bird Lake, 62°17'30"N 97°38'00"W, *K. Reading 437*, 25 June 1985 (DAO); 62°20'00"N 97°22'00"W, *K. Reading 32*, 16 July 1985 (DAO); Pebble Beach Lake south of Yathkyed Lake, 62°22'00"N 97°30'00"W, *K. Reading 149*, 16 July 1985 (DAO) (determined by G. Argus).

The Windy Lake specimen cited above is an extension of the known range in the District of Mackenzie of about 170 kilometers from sites adjacent to Bathurst Inlet south of latitude 67°N reported by Cody et al. (1984). The District of Keewatin sites are midway between the Hudson Bay Coast and about longitude 98°W.

Salix reticulata L., Net-veined Willow – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 279*, 22 July 1987 (DAO); KEEWATIN: Camp 2, 61°21'00"N 97°53'31"W, *K. Reading 439*, 7 July 1990 (DAO); Washaneepisuki Lake, west of Imikula Lake, 62°12'30"N 97°52'00"W, *K. Reading 145*, 3 July 1984 (DAO); Pebble Beach Lake south of Yathkyed Lake, 62°22'00"N 97°30'00"W, *K. Reading 146*, 22 July 1985 (DAO) (determined by G. Argus).

The first specimen cited above is an extension of the known range in the District of Mackenzie of about 170 kilometers northeast of a site at the south end of Bathurst Inlet (Porsild and Cody 1980). The District of Keewatin specimens are from sites midway between the Hudson Bay Coast and longitude 101°W (Porsild and Cody 1980).

Salix richardsonii Hook. (*S. lanata* L. ssp. *richardsonii* (Hook.) Hultén, Richardson's Willow – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Windy Lake, 68°03'15"N 106°37'00"W, *K. Reading 441, 445*, 7 July 1987 (DAO); Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'W, *K. Reading 275*, 10 Aug. 1987 (DAO); KEEWATIN: Big Bird Lake, south of Yathkyed Lake, 62°17'30"N 97°38'00"W, *K. Reading 150*, 25 June 1985 (DAO); Pebble Beach Lake south of Yathkyed Lake, 62°22'00"N 97°52'00"W, *K. Reading 151*, 11 June 1985 (DAO) (determined by G. Argus).

The Mackenzie specimens cited above are an extension of the known range in the Territory of about 170 kilometers northeast of a site in the vicinity of Burnside Landing adjacent to Bathurst Inlet. The Keewatin specimens extend the known range in the Territory about 250 kilometers north from a site adjacent to the Manitoba border (Porsild and Cody 1980).

Salix rotundifolia Trautv. ssp. *rotundifolia,* Round-leaf Willow – MACKENZIE: Mackenzie Mountains, limestone, stoney tundra slope, 17 miles NW Little Divide Lake, 63°17'N 128°17'W, *W. J. Cody 16633,* 26 July 1967 (DAO); Mackenzie Mountains, in deep moss on granitic mountain, 5 miles SE of O'Grady Lake, 62°57'N 128°58'W, *W. J. Cody 16750,* 27 July 1967 (DAO); Mackenzie Mountains, 10 miles NE of O'Grady Lake, 63°05'N 128°50'W, *W. J. Cody 16889,* 29 July 1967 (DAO) (determined by G. Argus).

This willow was not included in the *Vascular Plants of Continental Northwest Territories* (Porsild and Cody 1980). It was however described and mapped by Argus in his *Guide to the identification of willows in Alaska, the Yukon Territory and adjacent regions* (Argus 2001). The specimens cited above are the basis for the maps in this treatment.

Salix sphenophylla A.K. Skvort. – MACKENZIE: delta low centre polygons, south of Big Lake, 69.3652°N 134.899°W, *D. Bush 25*, 2003 (DAO) (determined by G. Argus).

This species was reported as new to the Northwest Territories by McJannet et al. (1995) on the basis of a specimen collected by E. Kutke at Nig, 74 miles north of Inuvik (DAO). The specimen cited above is the second record for the Territory.

POLYGONACEAE

Polygonum viviparum L., Bistort – KEEWATIN: 62°08'50"N 97°53'00"W, *K. Reading 37*, 15 July 1984 (DAO); 62°12'00"N 97°52'00"W, *K. Reading 51*, 3 July 1984 (DAO).

The specimens cited above are from sites in the southern District of Keewatin about 150 kilometers east of a site just east of longitude 100°W (Porsild and Cody 1980).

CHENOPODIACEAE

Chenopodium dessicatum A. Nels. (*C. leptophyllum* Nutt.), Narrow-leaved Goosefoot – MACKENZIE: middle of open, revegetated sandy slope, 61.7441°N 121.1543°W, *L. Kershaw 5*, 2003.

Porsild and Cody (1980) reported *C. leptophyllum* as "In the Northwest Territories thus far known only from a Richardson specimen collected a Century and a half ago, at Fort Franklin, where it was surely an ephemeral introduction". The specimen cited above is from a site about half way between Fort Franklin and the west end of Lake Athabasca and may also be an ephemeral introduction.

CARYOPHYLLACEAE

Cerastium alpinum L. – MACKENZIE: siksik mound, Coppermine River Area, 67°32'30"N 116°01'30"W, *K. Reading 77*, 29 Aug. 2002 (DAO); Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 241*, 7 Aug. 1987 (DAO).

The first specimen cited above is an extension of the known range in the Territory of about 250 kilometers west of a site at the south end of Bathurst Inlet. The second specimen is an extension of the known range about 170 kilometers to the northeast (Porsild and Cody 1980).

Cerastium beeringianum Cham. & Schlecht. – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 214*, 10 Aug. 1987 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 170 kilometers to the northeast of the south end of Bathurst Inlet (Porsild and Cody 1980).

Minuartia biflora (L.) Schinzl. & Thell. – KEEWATIN: 11 miles south of east end of Bissett Lake, 63°39'10"N 95°10'00"W, *K. Reading 370*, 18 Aug. 1982 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 100 kilometers north of a site in the southern half of the Territory (Porsild and Cody 1980).

Minuartia rossii (R.Br.) Graebn. – KEEWATIN: Bissett Creek, 63°46'00"N 95°30'00"W, *K. Reading 368*, 25 July 1982 (DAO).

The specimen cited above is a westerly extension into central mainland Keewatin of 500 kilometers from sites on Southampton Island. To the north it is known from sites adjacent to the Arctic Coast and the Arctic Islands (Porsild and Cody 1980).

Minuartia rubella (Wahlenb.) Graebn. – KEEWATIN: south of east end of Bissett Lake, 64°40'30"N 95°12'00"W, *K. Reading 371*, 20 Aug. 1982 (DAO).

The specimen cited above is midway between a site adjacent to the Hudson Bay Coast and about 65°N 98°W (Porsild and Cody 1980).

Minuartia yukonensis Hultén – MACKENZIE: east bank of Mackenzie River, 68°52.1'N 134°29.8'W, *J.V. Matthews s.n.*, 4 Aug. 1983 (DAO); Mackenzie River Valley pipeline survey, Parson's Lake area, 68°59'05"N 133°30'59"W, *J. Lancaster s.n.*, 5 Aug. 2002 (DAO); Ya Ya esker, 69.2093°N 134.5636°W, *J. Lancaster 12A*, 9 July 2003 (DAO).

Porsild and Cody (1980) knew this Amphi-Beringian species in the Continental Northwest Territories only as far east as the east slope of the Richardson Mountains west of the Mackenzie Delta. The specimens cited above extend the known distribution eastward to part of the Mackenzie River and eastward further to Parson's Lake about 100 kilometers to the northeast.

Sagina caespitosa (J. Vahl) Lge. – KEEWATIN: TK Camp peninsula, Bissett Lake, 63°47'00"N 95°26'30"W, *K. Reading 367*, 17 July 1982 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 125 kilometers east of the northernmost site mapped by Porsild and Cody (1980).

Silene walensis (Rupr.) Bouquet (*Melandrium apetalum* (L.) Fenzl ssp. *arcticum* (Fr.) Hultén) – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 267*, 30 July 1987 (DAO); KEEWATIN: wet tundra rills, north of 30-mile lake, 63°46'00"N 96°07'00"W, *K. Reading 351*, 31 July 1981 (DAO).

The first specimen cited above is an extension of the known range in the Territory of about 170 kilometers northeast of a site at the south end of Bathurst Inlet (Porsild and Cody 1980). The Keewatin site is midway between the Hudson Bay Coast and sites just east of longitude 100°W.

Stellaria calycantha (Ledeb.) Bong. – KEEWATIN: Griffin Lake, 61°19'N 98°46'W, *K. Reading 340*, 10 Aug. 1990 (DAO); 62°11'N 97°52'W, *K. Reading 61*, 19 July 1984 (DAO); SY area, 62°12'10"N 97°53'00"W, *K. Reading 136*, 5 Aug. 1984 (DAO).

The specimens cited above extend the known range in the Territory about 180 kilometers north of a site north of the Manitoba border (Porsild and Cody 1980).

Stellaria longipes Goldie s.l. – MACKENZIE: scarp foot, Coppermine River Area, 67°07'N 115°05'W, *K. Reading 89*, 28 Aug. 2002 (DAO); KEEWATIN: east of Kazan River, north of Big Bend, 63°45'N 95°38'W, *K. Reading 399B*, 8 Aug. 1983 (DAO); south of Whale Lake, 63°46'N 96°06'W, *K. Reading 369*, 21 Aug. 1982 (DAO).

The first specimen cited above extends the known distribution about 250 kilometers west of the Burnside Landing area adjacent to Bathurst Inlet (Cody et al. 1984). The Keewatin specimens extend the known range to the northeast about 250 kilometers to the central area of Keewatin (Porsild and Cody 1980).

NYMPHAEACEAE

Nymphaea tetragona Georgi ssp. *leibergii* (Morong) Porsild – MACKENZIE: small lake in Camsell Ferry infrastructure midway on west shore of lake behind beaverlodge, 62.1567°N 122.4908°W, *L. Kershaw 15*, 2003 (DAO).

This rare plant in the Territory was first reported by A. E. Porsild (1939) on the basis of a collection by E. A. Preble from an island of the Simpson group 40 miles northeast of Resolution, Great Slave Lake. The specimen cited above is from a site about 425 kilometers to the west.

RANUNCULACEAE

Anemone parviflora Michx. – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Windy Lake, 68°03'15"N 106°37'00"W, *K. Reading 296*, 14 July 1987 (DAO); KEEWATIN: Big Bird Lake, 62°18'00"N 97°37'40"W, *K. Reading 440*, 28 June 1985 (DAO).

The first specimen cited above is an extension of the known range in the Territory of about 100 kilometers northeast of a site adjacent to Bathurst Inlet (Porsild and Cody 1980). The second specimen is an eastward extension of about 80 kilometers from a site just east of longitude 100°W.

Anemone richardsonii Hook. – KEEWATIN: creek into southwest corner of Pebble Beach Lake, 62°21'50"N 97°22'00"W, *K. Reading 443*, July 1985 (DAO).

The specimen cited above is encircled by six other sites in the southern half of the Territory (Porsild and Cody 1980).

Caltha natans Pall., Floating Marsh-marigold – KEEWATIN: northwest corner of Bissett Lake, 63°48'00"N 95°27'00"W, *K. Reading 345*, 8 Aug. 1983 (DAO).

This species is rare in the Continental District of Keewatin. The specimen cited above is an extension of the known range in the Territory of about 375 kilometers to the north and northeast from two sites in the south (Porsild and Cody 1980).

Caltha palustris L. var. *arctica* (R.Br.) Hultén, Marsh-marigold – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 273*, 24 July 1987 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 175 kilometers from the south end of Bathurst Inlet (Porsild and Cody 1980).

Ranunculus aquatilis L. var. *eradicatus* Laest., White Water Buttercup – MACKENZIE: lake bottom, Coppermine River Area, 67°32'50"N 116°13'00"W, *K. Reading 75*, 23 Aug. 2002 (DAO).

The specimen cited above is from a site midway between the south end of Bathurst Inlet and the east end of Great Bear Lake (Porsild and Cody 1980).

Ranunculus sabinei R.Br. – KEEWATIN: Fly Camp 3, 65°53'N 98°34'W, *S. Smith 204*, 20 July 1983 (DAO); big esker south of Bissett Lake, 63°40'40"N 95°32'00"W, *K. Reading 373*, 16 Aug. 1981 (DAO); 62°11'00"N 97°55'00"W, *K. Reading 60*, 13 July 1984 (DAO).

The specimens cited above extend the known distribution in the Territory south of the Arctic Coast into central District of Keewatin (Porsild and Cody 1980).

Ranunculus ×spitzbergensis (Nath.) Hadac – KEEWATIN: This hybrid of *Ranunculus lapponicus* × *R. pallasii* was reported by Cody et al. (1988) on the basis of a specimen collected by K. Reading at Jaeger Creek, 62°11'20"N 97°53'00"W in 1984 and also from northern Quebec.

PAPAVERACEAE

Papaver radicatum Rottb. – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 251*, 4 Aug. 1987 (DAO).

The specimen cited above is an extension of the known range in the Territory to the northeast of a site about 170 kilometers from the south end of Bathurst Inlet (Porsild and Cody 1980).

BRASSICACEAE (CRUCIFERAE)

Braya glabella Richardson – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 485*, 12 Aug. 1987 (DAO) (determined by G.A. Mulligan).

The specimen cited above is an extension of the known range in the Territory of about 170 kilometers northeast of the south end of Bathurst Inlet (Porsild and Cody 1980) and is the northeasternmost site yet known in the Territory.

Braya humilis (C.A. Mey.) Robins. – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 486*, 13 Aug. 1987 (DAO) (determined by G. A. Mulligan).

The specimen cited above is an extension of the known range in the Territory of about 170 kilometers northeast of a site west of Bathurst Inlet and is the northeasternmost yet known in the Territory (Porsild and Cody 1980). To the north it is known on Victoria Island.

Cardamine bellidifolia L. – MACKENZIE: dolomite ridge, Coppermine River area, 67°07'00"N 115°45'00"W, *K. Reading 91*, 28 Aug. 2002 (DAO); KEEWATIN: 62°10'30"N 97°59'00"W, *K. Reading 474*, 17 Aug. 1984 (DAO); 62°12'00"N 97°53'00"W, *K. Reading 475*, 4 Aug. 1984 (DAO) (determined by G. A. Mulligan).

The Mackenzie specimen cited above is an extension of the known range in the Territory of about 250 kilometers northwest of the south end of Bathurst Inlet. To the west it is unknown between there and the Richardson and Mackenzie mountains (Porsild and Cody 1980). The Keewatin specimens cited above are extensions of the known range in the Territory of about 70 kilometers east of the southwesternmost site mapped by Porsild and Cody (1980).

Cardamine pratensis L. Lady's-smock – KEEWATIN: 62°10'00"N 97°54'00"W, *K. Reading 484*, 17 July 1984 (DAO); Pebble Beach Lake, 62°21'58"N 97°30'02"W, *K. Reading 483*, 10 July 1985 (DAO); south of Bissett Lake, 63°43'N 95°18'W, *K. Reading 482*, 22 July 1982 (DAO) (determined by G. A. Mulligan).

The first two specimens cited above are from sites midway between sites near the Hudson Bay Coast and longitude 100°W. The third specimen cited above is the northernmost yet found in the Territory from south of the Arctic Circle (Porsild and Cody 1980).

Descurainia sophioides (Fisch. ex Hook.) O.E. Schulz – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 254*, 3 Aug. 1987 (DAO) (determined by G. A. Mulligan).

The specimen cited above is an extension of the known range in the Territory of about 100 kilometers northeast of a site on the west side of Bathurst Inlet (Porsild and Cody 1980).

Draba fladnizensis Wulf – KEEWATIN: 62°12'30"N 97°52'00"W, *K. Reading 507*, 3 July 1984 (DAO) (determined by G.A. Mulligan).

The specimen cited above is an extension of the known range in the Territory of about 200 kilometers southeast of a site adjacent to Chesterfield Inlet (Porsild and Cody 1980) (determined by G. A. Mulligan).

Draba juvenalis Kom. (*D. longipes* Raup) – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 500*, 12 Aug. 1987 (DAO) (determined by G. A. Mulligan).

The specimen cited above is an extension of the known range in the Territory of about 500 kilometers northeast of the east end of Great Bear Lake. To the northeast it is known from two localities on southeastern Victoria Island (Porsild and Cody 1980).

Draba nivalis Liljebl. – KEEWATIN: Pebble Beach Lake, 62°21'40"N 97°29'54"W, *K. Reading 511*, 28 June 1985 (DAO); 62°11'00"N 97°55'00"W, *K. Reading 510*, 13 July 1984 (DAO) (determined by G. A. Mulligan).

The specimens cited above are from sites midway between sites in the central area of the Territory south of the Arctic Circle and a site in the southeast adjacent to latitude 100°W (Porsild and Cody 1980).

Draba wahlenbergii Hartm. (*D. lactea* Adams) – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 497*, 13 July 1990 (DAO); *K. Reading 501*, 13 Aug. 1987 (DAO); *K. Reading 508*, 12 Aug. 1987 (DAO); KEEWATIN: Camp 3, 61°12'N 97°57'W, *K. Reading 499*, 13 July 1990 (DAO); 62°10'30"N 97°59'00"W, *K. Reading 502*, 17 Aug. 1984 (DAO); Imikula Lake, 62°14'00"N 97°37'00"W, *K. Reading 504*, 18 June 1985 (DAO); Big Bird Lake, 62°17'30"N 97°39'00"W, *K. Reading 503*, 27 June 1985 (DAO); Pebble Beach Lake, 62°22'00"N 97°30'00"W, *K. Reading 506*, 7 July 1985 (DAO) (determined by G. A. Mulligan).

The District of Mackenzie specimens cited above are from sites about 170 kilometers northeast of the south end of Bathurst Inlet. To the north it is known from southern Victoria Island and is widespread throughout the Arctic Islands. The District of Keewatin specimens are sites midway between sites adjacent to the Hudson Bay Coast and the Mackenzie-Keewatin border and south of sites north of latitude 63°N (Porsild and Cody 1980).

Erysimum pallasii (Pursh) Fern. – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Windy Lake, 68°03'11"N 106°37'00"W, K. Reading 298, 14 July 1987 (DAO); KEEWATIN: north side of Mire Creek, 61°21'00"N 97°53'30'W, K. Reading 514, 2 July 1990 (DAO) (determined by G. A. Mulligan).

The first specimen cited above is an extension of the known range in the Territory of about 170 kilometers northeast of the south end of Bathurst Inlet (Porsild and Cody 1980). The second specimen is a new record for the District of Keewatin and is an extension of about 765 kilometers southeast of the south end of Bathurst Inlet.

Eutrema edwardsii R.Br. – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Windy Lake, 68°03'15"N 106°37'00"W, *K. Reading 295*, 14 Aug. 1987 (DAO) (determined by G. A. Mulligan).

The specimen cited above is an extension of the known range in the Territory of about 170 kilometers to the northeast from the south end of Bathurst Inlet. To the north it is known on Victoria Island and it is widespread on the Arctic Islands (Porsild and Cody 1980).

Parrya arctica R.Br. – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 476*, 10 Aug. 1987 (DAO) (determined by G. A. Mulligan).

The specimen cited above is an extension of the known range in the Territory of about 375 kilometers east of a site west of Coronation Gulf. To the north it is known from Victoria Island and is widespread on the Arctic Islands west of longitude 90°W (Porsild and Cody 1980).

SAXIFRAGACEAE

Chrysosplenium tetrandrum (Lund) Fries – MACKENZIE: rocky lakeshore, Coppermine River Area, 67°33'30"N 116°45'00"W, *K. Reading 44*, 21 Aug. 2002 (DAO).

The specimen cited above is from a site midway between the south end of Bathurst Inlet and Coppermine (Porsild and Cody 1980).

Saxifraga nelsoniana D. Don ssp. *porsildiana* (Calder and Savile) Hultén (*S. punctata* L. ssp. *porsildiana* Calder & Savile) – KEEWATIN: Pebble Beach Lake, south of Yathkyed Lake, 62°22'00"N 97°30'00"W, *K. Reading 175*, 22 July 1985 (DAO).

The specimen cited above is an extension of about 250 kilometers south of the site reported by Cody et al. (2003).

Saxifraga nivalis L., Alpine Saxifrage – MACKENZIE: wet tundra below scarp, Coppermine River Area, 67°31'12"N 116°09'58"W, *K. Reading 64*, 22 Aug. 2002 (DAO); scarp foot wet, Coppermine River Area, 67°32'28"N 116°01'00"W, *K. Reading 82*, 30 Aug. 2002 (DAO).

The specimens cited above are from sites midway between Bathurst Inlet and Coppermine (Porsild and Cody 1980).

Saxifraga rivularis L. – KEEWATIN: wet shaded rocky ravine south of Wolf Lake, 63°39'00"N 95°11'00"W, *K. Reading 360*, 16 Aug. 1982 (DAO); big esker south of Bissett Lake, 63°40'40"N 95°32'00"W, *K. Reading 374*, 16 Aug. 1981 (DAO); east of Bissett Lake, 63°46'00"N 95°46'00"W, *K. Reading 342*, 27 July 1982 (DAO).

The specimens cited above are from sites midway between the Hudson Bay Coast and sites adjacent to longitude 100°W (Porsild and Cody 1980).

ROSACEAE

Potentilla biflora Willd. – MACKENZIE: wet tundra, Coppermine River Area, 66°43'10"N 114°58'00"W, *K. Reading 523*, 7 Sept. 2002 (DAO); rocky tundra and basalt outcrops, Coppermine River Area, 67°21'00"N 115°51'00"W, *K. Reading 2*, 17 Aug. 2002 (DAO); scarp foot scree, 67°30'10"N 116°10'00"W, *K. Reading 524*, 22 Aug. 2002 (DAO); clay tundra boils, Coppermine River Area, 67°31'30"N 116°14'10"W, *K. Reading 525*, 19 Aug. 2002 (DAO); Dismal Lakes, 67°29'N 117°36'W, *L.W. Stock s.n.*, 8 Aug. 1947 (DAO).

The nearest sites of this species to those listed above in this Territory are in the vicinity of the Bluenose Lake Area about 500 kilometers to the northwest (Cody et al. 2003). There is also a site to the northeast on Victoria Island (Porsild and Cody 1980).

Potentilla nivea L. ssp. *nivea* – KEEWATIN: high dry esker-top, east of Kazan Falls, 63°41'N 95°38'W, *K. Reading 354*, 30 Aug. 1982 (DAO); west southwest of Bissett Lake, 63°44'30"N 95°28'00'W, *K. Reading 334*, 4 Aug. 1982 (DAO); TK camp peninsula, Bissett Lake, 63°47'00"N 95°26'30"W, *K. Reading 379*, 9 Aug. 1982 (DAO).

The specimens cited above are an extension of the known range in the Territory of about 170 kilometers northeast of a site mapped by Porsild and Cody (1980).

Potentilla palustris (L.) Scop., Marsh Fivefinger – KEEWATIN: south of Deep Bay of Kazan River, 63°41'30"N 95°37'00"W, *K. Reading 333*, 3 Aug. 1982 (DAO).

The specimen cited above is an extension of the known range of about 170 kilometers northeast of a site in central Keewatin mapped by Porsild and Cody (1980).

Rosa blanda Ait. – MACKENZIE: Mackenzie River Valley survey, Creek bank, 64°35'23"N 124°48'22"W, *B. Cornish s.n.*, 17 July 2002 (DAO).

Porsild and Cody (1980) knew this species in the Territory only from the vicinity of Wrigley. The specimen cited above is an extension of the known range of about 160 kilometers to the northwest.

Rubus arcticus L. ssp. *acaulis* (Michx.) Focke – KEEWATIN: Griffin Lake, 61°14'55"N 98°46'00"W, *K. Reading 89*, 10 Aug. 1990 (DAO).

The specimen cited above is from a site midway between two sites mapped by Porsild and Cody (1980) in southwestern District of Keewatin.

Rubus idaeus L. s.l. (*R. strigosus* Michx.), Wild Red Raspberry – KEEWATIN: Griffin Lake, 61°18'40"N 98°52'00"W, *K. Reading 532*, 14 Aug. 1990 (DAO).

Porsild and Cody (1980) knew this species from a single location in the southwest of the Territory. The specimen cited above is an extension of about 100 kilometers to the north.

FABACEAE (LEGUMINOSAE)

Astragalus australis (L.) Lam. (*A. richardsonii* Sheldon) – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 264*, 30 July 1987 (DAO).

The specimen cited above is an extension of the known range in the Territory (Porsild and Cody 1980) of about 170 kilometers northwest of the south end of Bathurst Inlet. To the north it is also known from Victoria Island.

Astragalus eucosmus Robins. – KEEWATIN: west side of Kneeling Man Lake, south of Yathkyed Lake, 62°19'30"N 97°33'20"W, *K. Reading 187A*, 17 July 1985 (DAO); "No-camp" Lake south of Yathkyed Lake, *K. Reading 85-17*, 15 July 1985 (DAO); "Pebble Beach" Lake, south of Yathkyed Lake, 62°22'M 97°30'W, *K. Reading 85-26*, 17 July 1985 (DAO); vicinity of Meliadine Lake, 63°01'44"N 92°10'51"W, *K. Reading 94-26*, 1984 (DAO); on rock outcrop, Rankin Inlet 5 km northwest of town, 62°49'N 92°05'W, *J. B. Korol s.n.*, 19 July 1988 (DAO).

The specimens cited above are the first known from the Continental District of Keewatin (Porsild and Cody 1980).

Astragalus eucosmus Robins. f. *albinus* Fern. – KEEWATIN: north end of No-camp Lake, south of Yathkyed Lake, 62°22'15"N 97°27'10"W, *K. Reading 382*, 15 July 1985 (DAO).

This white-flowered form was described by Fernald (1926) on the basis of a specimen from Ha-Ha Mountain in Newfoundland. The specimen cited above is the first known from the Continental Northwest Territories.

Hedysarum alpinum L., Liquorice-root – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 236*, 8 Aug. 1987 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 80 kilometers from a site in the middle of Bathurst Inlet. It is the most northeastern site yet known in the Territory.

Hedysarum boreale Nutt. ssp. *mackenzii* (Richards.) Welsh (*H. mackenzii* Richards.) – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 237*, 8 Aug. 1987 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 170 kilometers northeast of the south end of Bathurst Inlet (Porsild & Cody 1980). To the north it is known on Victoria Island.

Lupinus arcticus Wats. – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 237*, 2 Aug. 1987 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 170 kilometers to the northeast of the south end of Bathurst Inlet. To the northeast it is known on Victoria Island (Porsild and Cody 1980).

Oxytropis arctobia Bunge – MACKENZIE: George Lake, south of Bathurst Inlet at the head of Western River, approx. 65°57'20"N 107°30'W, *K. Reading 451*, 18 Aug. 1988 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 75 kilometers south of the south end of Bathurst Inlet (Porsild and Cody 1980).

Oxytropis deflexa (Pall.) DC. ssp. *foliosa* (Hook.) Cody – MACKENZIE: Amphibolite ridge crown, north of the east arm of Great Slave Lake, 62°42'N 113°05'W, *K. Reading 12*, 13 Sept. 2002 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 27 kilometers east of a site in the vicinity of Yellowknife (Cody et al. 2003).

Oxytropis maydelliana Trautv. – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 224*, 8 Aug. 1987, *244*, 6 Aug. 1987 (DAO).

The specimens cited above are an extension of the known range in the Territory of about 170 kilometers northeast of the south end of Bathurst Inlet. To the northeast it is known on Victoria Island (Porsild and Cody 1980).

CALLITRICHACEAE

Callitriche hermaphroditica L. – MACKENZIE: silty lake bottom, Coppermine River Area, 67°32'55"N 116°13'00"W, *K. Reading 540*, 23 Aug. 2002 (DAO).

The specimen cited above which is the northwesternmost yet found in the Territory, is an extension of the known range of about 170 kilometers to the northwest from a site near the east end of Great Bear Lake (Porsild and Cody 1980).

ELEAGNACEAE

Shepherdia canadensis (L.) Nutt., Soapberry – KEEWATIN: Camp 2, 61°21'00"N 97°53'30"W, *K. Reading 542*, 4 July 1990 (DAO).

The species is new to the flora of mainland Keewatin. It is a southeastward extension of the known range of about 425 kilometers from a site near the eastern limit of the District of Mackenzie (Porsild and Cody 1980).

ONAGRACEAE

Epilobium davuricum Fisch. – KEEWATIN: dark frost-boils, T-Bone Lake, SY, 62°13'N 97°53'W, *K. Reading 390*, 15 Aug. 1984 (DAO).

The specimen cited above is from a site midway between two sites in the Territory reported by Cody et al. (2003).

Epilobium latifolium L. f. *albiflorum* Nath. – KEEWATIN: Griffin Lake, 61°14'30"N 98°38'00"W, *K. Reading 544*, 17 Aug. 1990 (DAO).

Porsild and Cody (1980) stated that the flowers of this species were purple or rarely white, but no localities of the white flower form have previously been reported for this region.

Epilobium palustre L., Swamp Willowherb – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 247*, 6 Aug. 1987 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 170 kilometers to the northeast of a site near the south end of Bathurst Inlet (Porsild and Cody 1980).

HALORAGACEAE

Myriophyllum alterniflorum DC. – MACKENZIE: Panhandle Lake, SE of Parsons, 68.9104°N 121.555°W, *J. Lancaster 13*, 2003 (DAO).

This is a rare species in the Territory (McJannet et al. 1995). The specimen cited above is from a site about 185 kilometers northwest of a site adjacent to the northeast end of Great Bear Lake.

PYROLACEAE

Moneses uniflora (L.) Gray, One-flowered Pyrola – KEEWATIN: Griffin Lake, 61°16'40"N 98°42'00"W, *K. Reading 551*, 22 July 1990 (DAO); in white spruce copses on tundra, very local, small colonies, north of Griffin Lake, 61°02'N 98°12'W, *K. Reading s.n.*, 15 Aug. 1990 (DAO).

This species is new to Continental District of Keewatin. The nearest sites known to Porsild and Cody (1980) were near the east end of Great Slave Lake about 700 kilometers to the northwest and adjacent to Hudson Bay in the vicinity of Churchill, Manitoba, about 250 kilometers to the southeast.

Pyrola secunda L. s.l. – KEEWATIN: north of Bissett Lake, 63°48'30"N 95°24'00"W, *K. Reading 364*, 13 Aug. 1982 (DAO).

The specimen cited above is from the central part of the District of Keewatin about 200 kilometers south and 250 kilometers northeast of sites mapped by Porsild and Cody (1980).

ERICACEAE

Arctostaphylos alpina (L.) Spreng., Alpine Bearberry – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Windy Lake, 68°03'15"N 106°37'00"W, *K. Reading 291*, 7 July 1987 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 80 kilometers to the northeast of a site adjacent to Bathurst Inlet (Porsild and Cody 1980).

Ledum groenlandicum Oeder, Labrador-tea – KEEWATIN: UG Lake, 62°45'00"N 98°40'00"W, *K. Reading 454*, date unknown (DAO); lakeshore, northwest of Imikula Lake, 62°02'N 97°40'W, *K. Reading 459*, July-August 1984 (DAO).

The specimens cited above are the northernmost yet found in the Territory (Porsild and Cody 1980).

Vaccinium vitis-idaea L. var. *minus* Lodd., Mountain Cranberry – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 282*, 22 July 1987 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 80 kilometers to the east of a site on the west side of Bathurst Inlet (Porsild and Cody 1980).

GENTIANACEAE

Gentiana affinis Griseb. – MACKENZIE: Mackenzie River Valley pipeline survey, stream bed and low terraces along small creek/with gravel bars upstream, 63°22'38"N 123°29'35"W, *L. Kershaw s.n.*, 6 Aug. 2002 (DAO); riparian fluvial silt along river, 66.7082°N 129.3002°W, *L. Kershaw 8*, 2003 (DAO).

McJannet et al. (1995) knew this rare species in the Northwest Territories from locations at the west end of Great Slave Lake in the vicinity of Fort Good Hope, Mackenzie Mountains in the vicinity of the Keele River and near Fort Norman. The first specimen cited above is from north of Wrigley. The second specimen is the northernmost yet found in the Territory and is an extension of the known range of about 150 kilometers northwest of Fort Good Hope.

LAMIACEAE

Lycopus uniflorus Michx., Tuberous Water-horehound – MACKENZIE: muddy run south side of beaver lodge near NW corner lake, 62.9858°N 123.1755°W, *L. Kershaw 11*, 2003 (DAO).

This is a rare species in the Territory (McJannet et al. 1995), previously known from only east of the Slave River (Porsild and Cody 1980). The specimen cited above is an extension of the known range in the Territory of about 635 kilometers to the northwest.

SCROPHULARIACEAE

Lagotis glauca Gaertn. ssp. *minor* (Willd.) Hultén – MACKENZIE: hill west of Canoe Lake, head of creek, 68°15'N 135°54'W, *V. J. Krajina s.n.*, 11 Aug. 1965 (DAO).

The specimen cited above is from a site about 100 kilometers north of a site mapped by Porsild & Cody (1980). This site is the northernmost yet found in the Territory.

Limosella aquatica L., Mudwort – MACKENZIE: black spruce/Labrador Tea/cloudberry area in strip of exposed mud, 63.4867°N 123.6914°W, *L. Kershaw 10*, 2003 (DAO).

This is a rare species in the Territory (McJannet et al. 1995). The specimen cited above is from a site midway between the

east end of Great Bear Lake and a site adjacent to the Canol Road in the Yukon Territory.

Pedicularis capitata Adams – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 271*, 28 July 1987 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 80 kilometers east of a site on the west side of the north end of Bathurst Inlet (Porsild and Cody 1980).

Pedicularis langsdorfii Fisch. ssp. *arctica* (R.Br.) Pennell ex Hultén (*P. arctica* R.Br.) – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 272*, 26 July 1987 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 170 kilometers northeast of a site at the south end of Bathurst Inlet (Porsild and Cody 1980).

Pedicularis lapponica L., Lapland Lousewort – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°30'00"W, *K. Reading 234*, 8 Aug. 1987 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 170 kilometers northeast of the south end of Bathurst Inlet (Porsild and Cody 1980).

Pedicularis macrodonta Richards. (*P. parviflora* Smith ex Rees var. *macrodonta* (Richards.) Welsh – MACKENZIE: in graminoid/shrub fen with *Juncus stygius*, 60.6382°N 120.34633°W, *D. Soppet 16*, 17 Aug. 2003 (DAO).

This is a rare species in the District of Mackenzie (McJannet et al. 1995). The specimen cited above is only the second known in the Territory and is about 200 kilometers west of the west end of Great Slave Lake.

RUBIACEAE

Galium trifidum L. – KEEWATIN: among shoreline rocks just north of TK camp, Bissett Lake, 63°47'02"N 95°26'31"W, *K. Reading 358*, 30 Sept. 1982 (DAO).

The specimen cited above is the northernmost yet found in the Territory (Porsild and Cody 1980). It is about 300 kilometers north of the only site known to Porsild and Cody (1980).

CAPRIFOLIACEAE

Linnaea borealis L. var. *americana* (Forbes) Rehd., Twinflower – MACKENZIE: spruce "island" on dolomite ridge, Coppermine River Area, 67°07'00"N 115°45'00"W, *K. Reading 84*, 28 Aug. 2002 (DAO).

The specimen cited above is the most northeasterly yet found in the Territory (Porsild and Cody 1980). It is from a site about 250 kilometers northeast of the east end of Great Bear Lake.

CAMPANULACEAE

Campanula uniflora L. – KEEWATIN: west southwest of Bissett Lake, 63°43'20"N 95°30'00"W, *K. Reading 337*, 4 Aug. 1982 (DAO).

The specimen cited above is from a site midway between a site adjacent to the Hudson Bay Coast and a site adjacent to longitude 100°W (Porsild and Cody 1980).

ASTERACEAE

Antennaria isolepis Greene – KEEWATIN: south of east end of Bissett Lake, 63°43'00"N 95°11'00"W, *K. Reading 403*, 15 Aug. 1982 (DAO); south of Bissett Lake, 63°41'30"N 95°18'00"W, *K. Reading 418*, 22 July 1982 (DAO); 10 miles northeast of Bissett Lake, 63°56'99"N 95°07'00"W, *K. Reading 405*, 3 July 1981 (DAO).

The specimens cited above are from sites about 200 kilometers northeast and southeast of sites about longitude 99°W in the Territory (Porsild and Cody 1980).

Arnica angustifolia Vahl in Hornem. ssp. *attenuata* (Greene) Douglas & Ruyle-Douglas (*A. alpina* (L.) Olin ssp. *attenuata* (Greene) Maguire) – MACKENZIE: Coppermine River Area, scarp slope, *K. Reading 33*, 19 Aug. 2002 (DAO); foot of scarp in sand, 67°31'10"N 116°09'54"W, *K. Reading 54*, 22 Aug. 2002 (DAO); sand/gravel ridge, 67°23'45"N 116°27'00"W, *K. Reading 32*, 16 Aug. 2002 (DAO).

The specimens cited above extend the known distribution in the Territory about 170 kilometers to the northeast from a site adjacent to the southeast end of Great Bear Lake (Porsild and Cody 1980).

Arnica chamissonis Less. – MACKENZIE: Yellowknife Area, roadside clearing, Boulder Bay, 62°32'00"N 113°20'00"W, *K. Reading 11*, 11 Sept. 2002 (DAO).

The specimen cited above is from a site about 170 kilometers northwest of a site on the south side of eastern Great Slave Lake.

Artemisia furcata Bieb. (*A. hyperborea* Rydb.) – MACKENZIE: Coppermine River Area, 67°32'30"N 116°00'00"W, *K. Reading 582*, 29 Aug. 2002 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 160 kilometers to the southeast of a site west of Coppermine and northeast of a site at the west end of Great Bear Lake (Porsild and Cody 1980).

Artemisia tilesii Ledeb. s.l. – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, 68°10'30"N 106°33'00"W, *K. Reading 248*, 3 Aug. 1987 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 170 kilometers northeast of a site near the south end of Bathurst Inlet (Porsild and Cody 1980). It is the northeasternmost site yet known in the Territory.

Aster puniceus L., Purple-stemmed Aster – MACKENZIE: in calcareous area where stream widens and pools on flat area before flowing into mineral lake, Wrigley area, 62.7307°N 123.1098°W, *D. Soppet 26B*, 2003 (DAO).

Porsild and Cody (1980) suggested that this species should be looked for on the Salt Plain west of Fort Smith. The specimen cited above is from a site about 730 kilometers northwest of a site mapped near the west end of Lake Athabasca by Porsild and Cody.

Aster pygmaeus Lindl. – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 225*, 9 Aug. 1987 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 125 kilometers northeast of a site about the middle of Bathurst Inlet and it is the northeasternmost yet known in the Territory (Porsild and Cody 1980).

Aster sibiricus L. – MACKENZIE: Coppermine River Area, foot of scarp, sandy, 67°31'10"N 116°09'54"W, *K. Reading 55*, 22 Aug. 2002 (DAO); sandy slope near scarp, 67°32'50"N 116°13'00"W, *K. Reading 584*, 23 Aug. 2002 (DAO).

The specimens cited above are from sites midway between the south end of Bathurst Inlet and the vicinity of Coppermine (Porsild and Cody 1980).

Crepis nana Richards. – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Windy Lake, 68°03'15"N 106°37'00"W, *K. Reading 300*, 14 July 1987 (DAO); George Lake, south of Bathurst Inlet at the head of Western River, 65°57'20"N, 107°30'W, *K. Reading 453*, 18 Aug. 1988 (DAO); sandy ridge, Coppermine River Area, 67°24'00"N 116°24'00"W, *K. Reading 586*, 18 Aug. 2002 (DAO).

The first specimen cited above is an extension of the known range in the Territory of about 170 kilometers northeast of the south end of Bathurst Inlet. The second specimen is from a site about 170 kilometers northwest of the south end of Bathurst Inlet (Porsild and Cody 1980).

Erigeron uniflorus L. ssp. *eriocephalus* (Vahl. ex Hornem.) Cronq. (*E. eriocephalus* Vahl. ex Hornem.) – MACKENZIE: Coppermine River Area, sand ridge near creek, 67°23'00"N 116°27'00"W, *K. Reading 595*, 16 Aug. 2002 (DAO).

The specimen cited above is from a site midway between the vicinity of Coppermine and the south end of Bathurst Inlet (Porsild and Cody 1980).

Matricaria ambigua (Ledeb.) Kryl., Sea-shore Camomile – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 268*, 30 July 1987 (DAO); Windy Lake, 68°03'15"N 106°37'00"W, *K. Reading 290*, 7 July 1987 (DAO).

The specimens cited above are an extension of the known range in the Territory of about 170 kilometers northeast of the south end of Bathurst Inlet (Porsild and Cody 1980).

Senecio congestus (R.Br.) DC. – MACKENZIE: Hope Bay Area, northeast of Bathurst Inlet, Roberts Lake, 68°10'30"N 106°33'00"W, *K. Reading 232*, 10 Aug. 1987 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 170 kilometers to the northeast from the south end of Bathurst Inlet (Porsild and Cody 1980).

Solidago graminifolia (L.) Salisb. var. *major* (Michx.) Fern. (*Euthamis graminifolia* (L.) Nutt. var. *graminifolia*) – MACKENZIE: clearing with coarse rocks as soil base, #3 bay south of R.R.T.P. Camp, Tsu Lake, 60°35'N 111°52'W, *J. Thompson s.n.*, 19 Aug. 1980 (DAO); rocky shoreline, 250 metres west of Tsu Lake camp, 60°35'N 111°52'W, *D. Campbell s.n.*, 19 Aug. 1980 (DAO); river banks, 63.4719°N 123.7029°W, *L. Kershaw 27*, 2003.

Porsild and Cody (1980) and McJannet et al. (1995) knew this rare plant in the Territory only from the vicinity of Fort Simpson. The first two specimens cited above are from sites northeast of Lake Athabasca. The third specimen is a northward extension adjacent to the Mackenzie River of about 100 kilometers from the northernmost mapped by Porsild and Cody (1980).

Acknowledgments

We thank the many individuals who have contributed specimens to the DAO Herbarium; George Argus for the identification of *Salix*; Gerry Mulligan for the identification of Cruciferae; Leslie Cody for the many hours inputting this information on her computer; and Paul Catling for reviewing an earlier version of this manuscript.

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Received 20 October 2004
Accepted 11 March 2005

Notes

Apparent Predation by Gray Jays, *Perisoreus canadensis*, on Long-toed Salamanders, *Ambystoma macrodactylum*, in the Oregon Cascade Range

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Murray, Michael P., Christopher A. Pearl, and R. Bruce Bury. 2005. Apparent predation by Gray Jays, *Perisoreus canadensis*, on Long-toed Salamanders, *Ambystoma macrodactylum*, in the Oregon Cascade Range. Canadian Field-Naturalist 119(2): 291-292.

We report observations of Gray Jays (*Perisoreus canadensis*) appearing to consume larval Long-toed Salamanders (*Ambystoma macrodactylum*) in a drying subalpine pond in Oregon, USA. Corvids are known to prey upon a variety of anuran amphibians, but to our knowledge, this is the first report of predation by any corvid on aquatic salamanders. Long-toed Salamanders appear palatable to Gray Jays, and may provide a food resource to Gray Jays when salamander larvae are concentrated in drying temporary ponds.

Key Words: Gray Jay, *Perisoreus canadensis*, Long-toed Salamander, *Ambystoma macrodactylum*, amphibian, corvid, diet, larvae, pond.

Corvid birds are generalist feeders and "opportunistic" predators (Bent 1946; Marshall et al. 2003). In montane regions of western North America, corvids sometimes consume anuran amphibians, which can offer a concentrated food resource in breeding or larval rearing aggregations (Beiswenger 1981; Olson 1989; Corn 1993). Common Ravens (*Corvus corax*) and American Crows (*C. brachyrhynchos*) are predators of adult Western Toads (*Bufo boreas*) (Olson 1989; Corn 1993; Brothers 1994). Clark's Nutcrackers (*Nucifraga columbiana*) consume larval Columbia Spotted Frogs (*Rana luteiventris*) (Turner 1960; Pilliod 2002). Gray Jays (*Perisoreus canadensis*) prey upon larval *B. boreas* (Beiswenger 1981) and juvenile Boreal Chorus Frogs (*Pseudacris triseriata*) (Tordoff 1980). To our knowledge, there are no reports of corvids feeding on aquatic stages of salamanders. Here, we report Gray Jay predation on larval Long-toed Salamanders (*Ambystoma macrodactylum*) in the southern Cascade Range in Oregon.

We observed Gray Jay feeding behavior in the early afternoon of 2 October 2003 at a temporary pond on Whitehorse Bluff in Crater Lake National Park (elevation 1933 m; UTM Zone 10, E565248, N4747116; NAD27). This pond is located on a terrace with numerous other temporary ponds within a forest dominated by old-growth Mountain Hemlock (*Tsuga mertensiana*). When full after snowmelt, the observation pond covers an area of approximately 800 m^2 and has a maximum depth of 0.5 – 1 m. At the time of our observations, the pond had dried to a small pool (approximately 40 m^2) which was about 5% of the area covered when full. We observed two Gray Jays foraging at a muddy circular depression (0.3 m diameter) located 2 m from the only remaining pool in the pond basin. This depression was separated from the pool by dried mud. We observed no other similar saturated depressions within the pond basin. Each jay dipped its beak into the mud, lifted its head back, and vigorously shook its head from side to side several times. The jays flew from the pond into the forest canopy for several minutes before returning and repeating the behavior for another 1 – 2 minutes. This behavior of Gray Jays returning to perches between or after predation episodes has been noted in other observations of predation on amphibians and small mammals (Gill 1974; Tordoff 1980; Beiswenger 1981; Strickland and Ouellet 1993; Pilliod 2002). Our inspection of the muddy depression after the jays departed the vicinity revealed about 24 live Long-toed Salamander larvae. Salamanders were similarly sized (ca. 50 mm total length) and had full or partial gills. The tiny depression they occupied contained saturated mud but lacked surface water, macrophytic vegetation or any other visible material. We observed Gray Jay-sized tracks at other muddy locations within the basin of the pond. No other aggregations of stranded salamander larvae were found.

During a 70-min return visit on the afternoon of 12 October 2003, we observed no Gray Jays or Long-toed

Salamanders in or near the same pond perimeter. However, we found recent raven and Gray Jay-sized tracks at the former saturated depression (which had become flooded after an early snow) and along the margins of a separate neighboring pond, which also held shallow water. We observed no Gray Jays during a 90-min revisit on the afternoon of 21 October 2003, but fresh corvid-sized tracks were common in the muddy pond basin.

The foraging behavior of the Gray Jays, the abundance of Long-toed Salamanders, and the lack of surface water and alternative food items in the small depression lead us to conclude that the Gray Jays were consuming Long-toed Salamanders. Our observations are consistent with other descriptions of western corvids as opportunistic predators, and suggest that some salamander and anuran larvae are suitable prey for jays. Unlike some pond-breeding amphibians (see Kats et al. 1988), Long-toed Salamander larvae appear to be palatable to a variety of predators (Pilliod and Fronzuto 2005). Garter snakes (*Thamnophis* sp.) (Ferguson 1961), non-native fish (Tyler et al. 1998; Monello and Wright 2001), Northwestern Salamanders (*A. gracile*) (Hoffman and Larson 1999), conspecific larvae (Walls et al. 1993), giant water bugs (*Lethocerus* sp.) (CAP, personal observation), and dytiscid water beetles (Pilliod and Fronzuto 2005) consume larval Long-toed Salamanders.

Gray Jays are common at Crater Lake National Park and throughout much of the range of the Long-toed Salamander in mountain regions of western North America (Farner 1952; Strickland and Ouellet 1993; Marshall et al. 2003). Long-toed Salamanders often breed in temporary ponds, and larvae are likely to be stranded as water levels decline in late summer during dry years (Kezer and Farner 1955). The abundance of tracks at our observation pond suggests Gray Jays or other similarly sized birds visited this pond frequently. Long-toed Salamanders and other palatable amphibians may represent a seasonally important food resource to opportunistic corvid predators such as Gray Jays.

Acknowledgments

We thank B. McCreary, D. Olson, D. Pilliod, and A. J. Erskine for helpful reviews of the manuscript. The National Park Service Inventory and Monitoring Program provided support for portions of this research.

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Received 18 February 2004
Accepted 22 March 2005

Territorial Behavior in Belted Kingfishers, *Ceryle alcyon*, During Fall Migration

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Hamas, Michael J. 2005. Territorial behavior in Belted Kingfishers, *Ceryle alcyon*, during fall migration. Canadian Field-Naturalist 119(2): 293-294.

The Belted Kingfisher (*Ceryle alcyon*) exhibits territorial behavior during breeding and on the wintering grounds. However, behavior during migration is poorly documented. Here, I report on kingfishers exhibiting territorial behavior during fall migration along the shoreline of northern Lake Huron, Michigan.

Key Words: Belted Kingfisher, *Ceryle alcyon*, territorial behavior, migration, stopover, Lake Huron, Michigan.

The Belted Kingfisher (*Ceryle alcyon*) is widely distributed throughout temperate North America where breeding populations withdraw from northern latitudes and migrate south for the winter. Fall migration is apparent by mid-September, when birds begin to congregate along major waterways, and continues through November (Hamas 1994). Kingfishers are not known to travel in aggregated flocks, but in the Great Lakes region, Salyer and Lagler (1946) observed a continuous progression of individuals moving southward along the shoreline of Lake Michigan during October.

Like other migrants, kingfishers should seek stopover sites providing adequate resources that enable birds to continue their migration. Restricted to a diet that consists primarily of fishes and aquatic invertebrates, kingfishers' ability to find food during migration depends on clear water, in which prey are easily detected. Even wave action on lakes may determine where birds occur (Prose 1985). Thus, morphology of lacustrine shorelines may influence habitat selection by kingfishers at any time of year.

From 30 August until 23 September 2003, I observed solitary kingfishers along approximately 20 km of Lake Huron shoreline between Cedarville and DeTour Village in eastern upper Michigan. Forested peninsulas and intervening bays characterize the rocky shoreline where numerous emergent limestone boulders are erratically scattered in the shallow nearshore waters. With Great Lakes water levels at or near historical lows, kingfishers were unable to forage from tree branches overhanging water. Instead, birds either hovered over open water, or perched on emergent rocks from which they would dive for prey.

Kingfishers occurred at five different bays along the shoreline where diurnal variations in wind speed and direction sometimes generated waves that forced birds to move elsewhere. At Dudley Bay, however, which is protected from Lake Huron by a barrier island, wave action was minimal. No kingfishers occupied the bay during the breeding season, but three male kingfishers, two adults and one immature, partitioned the bay into contiguous territories which they defended for 11 consecutive days before departing. The birds were not marked, but individuals observed fishing from the same wooden dock or from the same exposed rocks daily were likely the same birds.

Agonistic encounters between birds included five chases observed on different days and an attack. Each interaction was accompanied by shrill rattling or screams, vocalizations typical of territorial disputes (Davis 1988). Observations were made from 06:15 – 07:30 EST when birds were likely to be foraging. Chases were initiated in response to an incursion by a conspecific into a portion of the bay occupied by another kingfisher. After driving an intruder from its territory, a pursuer would often return to the same fishing perch it occupied prior to the chase. Lincoln (1924) noted similar behavior in migrant kingfishers responding to humans. Sometimes, chases between birds over the tops of exposed boulders were saltatory. One bird repeatedly pursued an intruder which retreated to a nearby boulder, only to be pursued and displaced again.

The single attack occurred when an intruder being chased by another kingfisher retreated into its territory and landed on a dock. With its beak directed downward, the pursuer hovered less than 1 m over the perched bird which remained stationary, its crest erected and head thrown back. During the encounter, both birds were continuously emitting shrill screams. The pursuer then landed less than 2 m from the perched bird, and the two remained face to face, crests erected and vocalizing for nearly three minutes. The pursuer then returned to the portion of the bay from which the chase had originated.

Agonistic intraspecific interactions exhibited by kingfishers appear to occur throughout the year suggesting that continuous access to adequate prey is requisite and promotes territoriality wherever birds occur. During breeding, fishing areas are aggressively defended by both males and females, and overwintering territories are defended by solitary birds of all age classes, but may be temporarily abandoned during inclement weather (Davis 1980).

Although stopover territories are ephemeral, monopolizing access to prey is likely to enhance migrants'

foraging efficiency. At Dudley Bay none of the birds that I observed was marked, but 10 regurgitated pellets collected daily at the dock were likely from the same bird. Each pellet contained abundant fragments of crayfish exoskeleton in addition to some fish bones suggesting that kingfishers took prey that was most accessible and perhaps most abundant in the shallow waters of the bay. Knowing where to find food and excluding competitors in unfamiliar places are likely to enhance prospects for a successful migration (Moore 1999).

Acknowledgments

I am grateful to Marilyn Twining for lodging at Dudley Bay and her ongoing support for avian research along the shoreline of northern Lake Huron.

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Received 8 August 2004
Accepted 26 February 2005

First Record of Age 0+ Atlantic Whitefish, *Coregonus huntsmani,* from the Wild

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Hasselman, Dan J., Phillip Longue, and Rod G. Bradford. 2005. First record of age 0+ Atlantic Whitefish, *Coregonus huntsmani,* from the wild. Canadian Field-Naturalist 119(2): 294-295.

A small school of juvenile Atlantic Whitefish (~20-30 individuals) were observed in the littoral zone of Hebb Lake (Petite Rivière watershed), Nova Scotia in June 2000. Of these, a single individual was captured with a beach seine, and confirmed to be a young-of-the-year specimen. This is the first documented report of the occurrence of wild Atlantic Whitefish juveniles. Occupation of the littoral zone into early summer by young-of-the-year Atlantic Whitefish may have implications for predation by invasive Smallmouth Bass.

Key Words: Atlantic Whitefish, *Coregonus huntsmani,* wild juvenile, first record, Hebb Lake, Petite Rivière watershed, Nova Scotia.

On 26 June 2000, during daylight experimental angling on Hebb Lake (Petite Rivière watershed, Nova Scotia; N44°21'00; W64°34'00) to assess susceptibility of Atlantic Whitefish (*Coregonus huntsmani* Scott, 1987) to incidental capture, a school of small fish were observed in pursuit of an ~8cm in length floating imitation minnow during its retrieval to the shore from a cast destination of approximately ~3m depth. Although none of these fish were hooked, they remained near the shore for a sufficient period of time to determine that they were of similar size, silvery in colouration, and in possession of an adipose fin. A single Atlantic Whitefish (8.4 cm total length; 4.8 g total weight) was captured after re-casting the lure, and drawing a small-meshed beach seine behind and across the line of retrieval to bar escape. The specimen was aged (scale method), determined to be a young-of-the-year (y-o-y) specimen, and is archived at the Nova Scotia Museum of Natural History (Catalogue Number: NSM 85368).

These are the first observations of juvenile Atlantic Whitefish in the wild, as none were available to support previous taxonomic descriptions (Smith and Todd 1992; Edge et al. 1991; Piers 1927; Huntsman 1922) or ecological assessments (Edge and Gilhen 2001; Edge 1984, 1987). Recent (May-August, 2000) systematic temporal and spatial sampling with baited minnow pots, fyke nets, and beach-seines failed to collect a single specimen, although fish species known to frequent the shallow (≤1m) littoral zone of most Nova Scotia lakes (i.e., American Eel (*Anguilla rostrata*), Banded Killifish

(*Fundulus diaphanus*), Brown Bullhead (*Ameiurus nebulosus*), Creek Chub (*Semotilus atromaculatus*), Golden Shiner (*Notemigonus crysoleucas*), White Sucker (*Catostomus commersoni*), White Perch (*Morone americana*), and Yellow Perch (*Perca flavescens*)) were captured (R. G. Bradford, unpublished data). Similar findings were previously confirmed by Edge (1987).

Irrespective of the rarity of known occurrences of juvenile Atlantic Whitefish within inshore areas of shallow–moderate depth, there are indications that the species is not precluded from occupation of zones of warmer water temperatures. Young-of-the-year Atlantic Whitefish reared in captivity routinely tolerate summer temperatures of up to 24°C (John Whitelaw, Department of Fisheries and Oceans, Mersey Biodiversity Centre, Milton, Nova Scotia, personal communication). Recorded June water temperatures at 1 m depth in Hebb Lake are a comparable 19.9° ± 3.2°C (mean ± s.d.), and range from 14.2° to 26.1°C (R. G. Bradford, unpublished data). Young coregonids generally tolerate higher temperatures than do their adult counterparts (Fry 1937). Therefore, the presence of y-o-y Atlantic Whitefish in lacustrine habitat shallower than the depth of the summer hypolimnion cannot be discounted.

These observations have significance as an indication that small-bodied Atlantic Whitefish may be susceptible to direct predation by Smallmouth Bass (*Micropterus dolomieu*), a non-native invasive species illegally introduced into the upper Petite Rivière drainage during the late 1990s (J. Gilhen, Nova Scotia Museum of Natural History, personal communication; Atlantic Whitefish Conservation and Recovery Team 2004). Smallmouth Bass now reproduce successfully in Minamkeak Lake, the upper most of three lakes that, when combined, total no more than 16 km^2 of aquatic habitat, and represents the global distribution of Atlantic Whitefish (Bradford et al. in preparation). Colonization of the other two lakes by smallmouth bass is probable in light of the experience with this aquatic invasive species elsewhere in North America (Vander Zanden et al. 1999, 2004). Occurrence of y-o-y Atlantic Whitefish in the limnetic zone during the seasons of active foraging by Smallmouth Bass may therefore be a matter of importance to the survival of the species, but further study is required to determine the validity of this supposition.

Acknowledgments

Observations occurred during field activities in support of the Atlantic Whitefish recovery strategy. Funding was provided by the Canadian Department of Fisheries and Oceans.

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Received 2 November 2004
Accepted 12 March 2005

Passage Through a Small Drainage Culvert by Mule Deer, *Odocoilus hemionus,* and Other Mammals

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Krawchuk, Alissa, Karl W. Larsen, Richard D. Weir, and Helen Davis. 2005. Passage through a small drainage culvert by Mule Deer, *Odocoilus hemionus,* and other mammals. Canadian Field-Naturalist 119(2): 296-298.

Cameras with infra-red triggers were used to monitor the passage of wildlife through underground passages that ran under a major highway and railway. Several species of mammals were detected traveling through the passages; of particular interest was the movement of Mule Deer (*Odocoileus hemionus*) through a relatively small culvert that would not have been predicted to see usage by these animals.

Key Words: road crossing, Mule Deer, *Odocoilus hemionus*, Black Bear, *Ursus americanus,* road ecology, underpass, highway crossing.

Numerous types of crossing structures exist to aid in the movement of wildlife across highways and railways. Some of these structures, such as drainage culverts, cattle underpasses and human underpasses, are not specifically designed for use by wildlife, yet they are ubiquitous features associated with highways, and are far more common than underpasses and overpasses specifically designed for wildlife. To this end, their potential and realized roles in reducing negative road effects on wildlife need to be explored. Culverts, for example, are known to be used by numerous types of wildlife including small mammals, reptiles, amphibians and large carnivores (Yanes et al. 1995; Rodriguez et al. 1996; Clevenger et al. 2001).

Interest in the ability of crossing structures to lower deer mortality on highways grew in the 1970s in response to large numbers of these animals being struck by vehicles in the United States (Puglisi et al. 1974; Allen and Cullough 1976). In particular, Reed et al. (1975, 1979) studied the use of underpasses by Mule Deer, *Odocoilus hemionus*, and as a result, the suitability of crossing structures for deer was well documented. Reed et al. (1975, 1979) identified the openness ratio (width*height/length) of these structures as an important factor influencing deer use. Their work suggested that structures with openness ratios of less than 0.6 would not be utilized by deer. This minimum guideline is somewhat difficult to test, as structures monitored for wildlife passage often are much larger (Yanes et al. 1995; Foster and Humphry 1995). One recent study that examined small crossings found that deer would use culverts as small as 4.2 m wide, 3.5 m tall, and 96.1 m long (openness ratio of 0.15, Clevenger and Waltho 2000). In the same study, deer also were found to use underpasses as large as 14.9 m wide, 3.2 m tall and 38.0 m long (openness ratio of 1.25).

We conducted a small, localized study to document whether or not wildlife was using various passages under major transportation corridors in the region surrounding Kamloops, British Columbia. Herein we report on our results, particularly the repeated use of an unusually small culvert by deer.

Methods

This study took place in the fall of 2003. We chose three crossing structures (two drainage culverts and one cattle underpass) east of Kamloops, British Columbia (119°52'W, 50°39'N) to monitor with infra-red sensor cameras. Each of these three crossings extends under both the Trans-Canada Highway and the Canadian Pacific Railway. The former is the major transportation corridor for motorists traveling through the Kamloops region. Monthly average daily traffic on this road for September to November ranges between 10 000 and 15 000 vehicles per day (British Columbia Ministry of Transportation, Transportation Information Management System data [1997-1999]). At two of the three sites we monitored (Site 1 and 2), the highway consisted of four lanes for at least 1 km in either direction. The dimensions of the crossing structures at the three sites are summarized in Table 1 (see Figure 1).

We used camera units (MacHutchon et al. 1998) constructed from 35 mm cameras with autofocus, wide angle lens, autoflash and date/time function (Olympus Af-1 Twin, Japan). These units were linked to passive infra-red sensors (Sureshot 6257-SPDT, Sentrol, USA) and hooked through a converter and an on/off switch to a 12 volt battery. The sensors were sensitive enough to be triggered by very small movements such as a breeze gently moving plants or a small animal passing by, if the movement was close enough to the camera (within 20 m). The entire assembly was housed in a modified ammunition box that had been painted black.

The camera boxes were attached to right-angle brackets that allowed mounting on trees or fenceposts. The boxes also could be anchored directly to the ground, in situations where suitable mounting support was unavailable. Due to site characteristics and a limited availability of mounting structures, it was not always possible to position the cameras directly facing the

TABLE 1. Crossing occurrence of wildlife in culverts, as detected by infra-red sensors and cameras near Kamloops, British Columbia, autumn 2003.

Location	Passage Width (m)	Passage Height (m)	Passage Length (m)	Openess Ratio (width*height /length)	Species detected	Number of detected crossings
Site 1*	2.1	1.5	30	0.11	Black Bear	20
					Mule Deer	6
Site 2**	7.0	5.0	40	0.88	Black Bear	4
					Raccoon	2
Site 3***	1.2	1.2	30	0.05	none detected	-

* camera operational August 21 to November 13, 2003 (Figure 1)
** camera operational August 30 to November 13, 2003
*** camera operational September 5 to November 13, 2003

culverts. We also tried to position the cameras so that the flash would not go off directly in the eyes of any wildlife using the structure, thereby startling them and possibly discouraging use.

We visited each site and its camera station every few days, depending on the frequency of pictures taken and the battery strength. A spare battery allowed for rotation between the three cameras with minimal camera downtime. At each camera check, the battery strength and the number of exposures were noted. The presence of animal tracks or sign around the camera station also was noted, to confirm that the cameras were not missing animals. From the developed photos, we counted the number of animals of each species detected at each camera. When the same animal was seen in a sequence of photos, it was only counted as one crossing event.

Results

Despite the brevity of the study and the small number of locations monitored, we were successful at detecting use of the crossing structures at two of three camera sites. Table 1 summarizes the native species documented using the crossing structures. Non-wildlife use detected by the cameras included humans, cattle

FIGURE 1. Drainage culvert at Site 1, used repeatedly by Mule Deer to travel under the Trans-Canada Highway near Kamloops, British Columbia (dimensions of culvert: 2.1 m wide, 1.5 m tall, 30 m long).

and housecats. No photo of wildlife crossing was obtained at Site 3; however, a faulty flash mechanism on the camera at this site rendered all night-time photos indecipherable, so we simply may have failed to detect animals using this culvert for passage.

Mule Deer were detected traveling through the Site 1 culvert that had an openness ratio of only 0.11 (Table 1). The camera at this site recorded Mule Deer on six different occasions over the 10-week study. This culvert had a dirt substrate, was surrounded on either side by vegetation, and was relatively far from human activity. Deer were not detected at Site 2, however, a road-killed deer was found within 50 m of the culvert during the study period, suggesting deer were in the vicinity. Deer also were not detected at Site 3, possibly due in part to the faulty flash (see above), but deer tracks were seen in the area of the underpass during the study period.

Discussion

Our general observations of Black Bear, *Ursus Americanus*, Raccoon, *Procyon lotor*, and Mule Deer passing through the monitored culverts are in keeping with results from other studies (e.g., Clevenger and Waltho, 2000; LaPoint et al. 2003). However, of particular interest is the use of the drainage culvert at Site 1 by Mule Deer, as previous work has suggested that ungulates are reluctant to use structures less than 7 m wide or 2.4 m high, or with an openness ratio of less than 0.6 (Reed et al. 1975; Reed et al. 1979; Yanes et al. 1995). This is substantially greater than the ratio for the culvert at Site 1 in this study. However, Clevenger and Waltho (2000) recently reported on the use by deer of an underpass with an openness ratio of 0.15 in Banff, which together with our study supports the notion that deer may be more plastic in their use of crossing structures than previously thought.

Our failure to detect deer crossing at Sites 2 and 3 (even though evidence showed deer were in the area) likely is due in part to our small sampling period, and a host of other potential factors (Rodriguez et al. 1996, Clevenger et al. 2001). Unlike Site 1, the culverts at Site 2 and 3 lacked a large amount of surrounding natural vegetation, a feature found to increase the use of crossings by wildlife (Yanes et al. 1995). The natural dirt substrate on the bottom of the culvert at Site1 also may have encouraged its use by deer, as a substrate of soil and detritus has been reported to be less hostile to wildlife (Reed et al. 1975; Yanes et al. 1995). Further, it has been suggested that elevated noise levels associated with human activity deter wildlife from utilizing culverts close to such areas (Clevenger et al. 2000), and the Site 1 culvert, where deer were detected, was relatively far away from human activity.

Despite the limitations of our study, we documented the passage of Mule Deer under a major highway, through a culvert that would not have been predicted to show usage by these animals. Our observations suggest further research is required on the use or avoidance of culverts and other structures not specifically designed for wildlife.

Acknowledgments

The Smith family graciously allowed us to set up a monitoring camera on their property near Pritchard, British Columbia. Thanks to E. Lofroth and T. Hamilton for facilitating this project. This study was funded by the Habitat Conservation Trust Fund of British Columbia.

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Received 27 September 2004
Accepted 6 February 2005

Book Reviews

ZOOLOGY

Birds of Azerbaijan

By Michael Patrikeev. 2004. Pensoft Publishers, Geo Milev Street 13a, 1111 Sofia, Bulgaria. 500 pages, U.S. $177.50 Cloth.

Several years ago I took a small map and shaded the countries for which you could purchase a good bird guide. There were two key gaps. One zone ran from eastern Turkey to Afghanistan (and the other was Brazil). The best books you could get for this former region (the Caucasus) was the Birds of Russia by Flint Boehme, Kostin and Kuznetsor or Birds of the Soviet Union by Dementiev and Gladkov (both nearly 50 years old). This new book covers the 372 species that have been recorded in the Republic of Azerbaijan and fills in some of that area with poor coverage.

Azerbaijan lies on the western shore of the Caspian Sea, to the north of Iran and east of Turkey. A southern section of Armenia clips off a small enclave called Noxçivan. It has a varied topography with the consequent diversity of bird species. This book covers this troubled region. There were wars in the 1800s with imperial Russia, civil war between 1917-1920, attacks by the Turks from the 1950s onwards, and still the area has an ongoing dispute with neighbouring Armenia. The struggles, along with changing economic and political status has led to some discontinuity in the study of birds. Separation from the USSR in 1991 lost the services of the Russian science community and this lack of continuous research shows in the data cited. Much of the information used by the author is from before the mid-1990s. There are some later references, but these are much fewer. Separation from the former USSR also caused economic difficulties from which the country has yet to emerge.

Birds of Azerbaijan is a distributional atlas, not a field guide. The author has compiled data from a large variety of sources, much from the "Russian" era. For example the data on Mallard is primarily prior to 1996. [We have seen with our work on the *Breeding Bird Atlas of Ontario* what an amazing difference a gap of ten years in the data can make]. The author has added his own extensive observations taken between 1970 and 1991. The story is quite gloomy. For example, many thousands of Red-breasted Geese were seen in the 1950s, but the species is considered virtually extinct now. Even the Eurasian Coot has dropped from millions to tens of thousands. The reasons for these changes include severe air, soil, and water pollution. Soil pollution results from oil spills, DDT and defoliants used in the production of cotton, making the Caspian Sea one the most ecologically degraded area in the world. Less gloomy, but equally distressing is the lack of current information on some species, for example Red Kite.

It is against this background that the author has done a sterling job of pulling the known information on this county's birds into a logical, readable text. Each species account has status, distribution, population size, migratory movements, breeding information, diet and mortality. The English names are used throughout, while Azaeri names are added for many species. A respectably-sized distribution map has codes for summer, winter, nesting, etc. for most species. The author gives an annotated bird list and describes important bird areas, places for colonial birds, waterfowl wintering areas, and the influence of cold winters and oil pollution. There are 78 photographs, of which one third show habitat, one third are bird photos and the rest are of eggs and nests. The habitat photographs show the nine basic types of landscapes from alpine meadows in mountains to semi-desert and wetland. But he does not illustrate the rust and mauve mountains of the Caucasus located in the troubled Naxçivan Autonomous District nor of any arid badlands. There is not full coverage of the 50 Important Bird Areas identified by the author.

Given the way the Azaeri economy has languished as regional trade has suffered and the underdeveloped oil production has yet to fulfill its promise, this book may be a very important milestone in a continuing tragic ornithological history.

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Birds of New Brunswick: An Annotated List

By David S. Christie, Brian E. Dalzell, Marcel David, Robert Doiron, Donald G. Gibson, Mike H. Lushington, Peter A. Pearce, Stuart I. Tingley, and James G. Wilson. 2004. New Brunswick Museum Monographic Series (Natural Science) Number 10, 277 Douglas Avenue, Saint John, New Brunswick, E2K 1E5. 2004. 83 pages. [Also available in French.]

This publication appeared in the same series as the two previous summaries (hereafter "lists") of bird status

in New Brunswick (Squires 1952, 1976), and seems to serve essentially the same purpose, to update the provincial bird list and the status of each species. This review considers the new publication's success in achieving its purpose, whether viewed only as an update of the earlier lists, or as state-of-the-art representation of each bird species' status in New Brunswick.

The subtitle "An annotated list" implies that this publication was planned as a less ambitious publication than its predecessors, but that may be a quibble. The earlier books were also annotated lists, though including more descriptive "front material" and fairly extensive bibliographies. The new species accounts generally are shorter than those in the earlier lists, omitting most place-names and dates – except for species known from very few records. Presumably that reflected more complete perspective on status than was available earlier, as might be expected; given 30 years' additional data, and their consideration by a panel of authors drawn from most parts of the province, it may have been redundant to document *in detail* the distribution of each species, many of which occur regularly in all or most of the 15 counties.

Considered only as an updated provincial list, with status assessed from existing, largely unstandardized data, I judge that this publication will serve most of its immediate objectives adequately. Birders will be able to find out whether a scarce species has been reported previously in New Brunswick and, if so, where and how many times. They also can obtain an idea, in very general terms, of how common a regular species is, across the province and in the seasons when it is to be expected.

Scientists seeking potential study areas may be dissatisfied with the scarcity of specific locations and of distributional limits within the province. Few "hot-spots" are identified except for very scarce species. Admittedly, scientists "from away" probably also had difficulty extracting such information from the earlier lists, owing to far greater gaps in knowledge then.

The introduction makes it clear that the present list, longer by 61 species than its 1976 predecessor, grew by addition largely of vagrants (= "lost birds"). Some new species had expanded their ranges, but very few of those – Mourning Dove the most obvious example – breed widely in New Brunswick as yet. Only two species were stated to have declined drastically, though other declines were noted in species accounts; my recent experience (quite limited geographically) suggested that some other declines may be as significant as those highlighted in the Introduction.

Perhaps a more important question emerging from review of this publication is whether its format was suitable for presenting status of all species **representatively**, even if we acknowledge that complete information will never be available? Status involves frequency of encounter and density, as well as distribution. Most observational effort by birders is notoriously uneven, focusing on "hot-spots" and easily accessible areas – and on misplaced species. Is it reasonable to accept that data from such efforts provide the best picture available on bird status?

The status of many *breeding* birds in New Brunswick was presented, probably more representatively (up to that time), in the maps and population estimates of the Maritimes Atlas (Erskine 1992). From the start of that (breeding) Atlas project, it was recognized that the major increases in perspective would emerge for species that were neither everywhere nor with very restricted breeding ranges – and that was found to be so. Although "abundance indices" were assessed for most species, and extrapolated to total breeding populations for many of them, no attempt has been made – as yet – to map relative densities of breeding species within New Brunswick from Atlas data. That would be essential for representative assessment of status, and it may soon become possible using "point-count" data to be collected in the second-generation bird atlas in the Maritimes (now in planning) [that in Ontario is nearing completion]. Breeding species make up most of the provincial list of *regularly occurring birds,* and Atlas data should be preferred over even up-to-date annotated lists by most scientists and many birders.

The Atlas mapping approach reduced unsampled areas greatly – though not completely. It could be used effectively only during breeding and wintering seasons, when birds are fairly sedentary. As yet, no bird atlas coverage is available in the Maritimes for winter or migration seasons – except for seabirds (which may not provide a model useful for other species). Many (uncompiled) data exist for other regular species in other seasons; although most were collected unsystematically and with no attempt at comprehensive coverage, it would be possible to produce maps for occurrence and frequency of wintering and migrating birds – in this and nearby provinces – that would improve greatly on the rather subjective status assessments available in check-list form. Until that is done, annotated lists may be the only readily available summaries of bird status in non-breeding seasons, including most occurrences of "displaced birds".

The new list of New Brunswick birds is a neat, compact publication, with a sturdy "ring" binding and attractive cover pictures. The front cover features an Evening Grosbeak, a colourful and conspicuous species that often dominated the New Brunswick bird scene in the 1970s – but that, in the past decade, has almost disappeared from southeast New Brunswick.

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Fishes of the Great Lakes Region Revised Edition

By Carl L. Hubbs and Karl F. Lagler. Revised by Gerald R. Smith. 2004. The University of Michigan Press, Ann Arbor, Michigan USA. xvii + 276 pages, plates 1-32. $24.95.

This book first appeared in 1941 in a different form and has had several subsequent editions. It is renowned for standardizing the methods for counting scales and fin rays and for measuring a fish specimen. This latest edition adds thirteen newly introduced species, plus hybrids between White Bass and Striped Bass, and geographical distribution maps for each species. It is much more user friendly than the 1964 edition. As was intended originally, this book is aimed at students and the ease with which this book can be used makes this point clear.

The Great Lakes region covers 287 770 square miles, while the Great Lakes themselves occupy 94 700 square miles of this area. Michigan is wholly encompassed by the region, as are small portions of other states bordering the lakes, but Ontario is the largest land area within the Great Lakes region so the book has a Canadian relevance. Within this region there are 28 families, 70 genera, 161 species and 215 forms of native fish. The term "form" is undefined, and seems to be used interchangeably with the term "kind". Presumably subspecies is meant. There are 210 species in total. Thirteen species and hybrids have been recently introduced by the construction of canals, by stocking, and through the dumping of ballast water from international freighters. Warning is given about the more destructive invaders' effects on the fish fauna and the loss of species that will result when the full effect is seen. The introductory sections of this book go into significant detail about the waters of the Great Lakes region, zoogeography, and the effects of postglacial redispersal.

The information in this book is generally well laid out. There is a section on the collection of fishes, on the preservation of fishes, and on how to identify these preserved fishes. All this information is very convenient for an amateur naturalist, including the description of the extent to which field notes should be made. These sections are brief, however, and are intended as basic information only.

There is a key to families and keys to identify species within families. The key to families is very easy to use, outlining the basic and most prominent features, allowing for quick and easy use, even by beginners. Not all the keys are together but the page references are clear. The species keys are also fairly easy to use, and the added line drawings can be helpful when identifying vague features but additional key features are in a second section after each key. There are 62 cyprinid species (carps and minnows) which makes it easy to go astray. Perhaps an initial key to genera would reduce the chance of error. Some exotics (Goldfish, Carp) are included in the key but others are not (Bighead, Black, Grass and Silver carp). A section on these "alien species" appears at the end of the key to Cyprinidae and might better be placed at the beginning, as would a section on hybridization in Cyprinidae.

Before each key there is a description of the family which is limited to physical features, geographical distribution, a brief biological outline, and occasionally the importance of the family to the fisheries. Species introduction dates and effects are included where applicable. After each key there is a list of all the species supplemented by a brief description, including physical features, geographical distribution, and what the species feeds on. The arrangement of species is not alphabetical by common name or by scientific name and does not follow the appearance of the species in the key, necessitating some searching in larger families. In addition to the descriptions there is a black-and-white photograph of the whole fish on the facing page as well as small line drawing of heads, spines, gill arches, mouths or other key features. The photos here, however, are not of the highest quality. In some cases, almost all detail is missing. The line drawings are small and often have no indication of the key structures so necessitating constant flipping between the key and the description section. The description has a tiny (22 × 16 mm) geographical distribution map. The maps are provided as a quick reference only since exact locations can scarcely be found. Larger maps are provided on the inside of each cover, in significantly more detail, allowing for some cross-referencing. Ontario and Quebec records of the Chestnut Lamprey are not apparent, the Carp and Freshwater Drum are not recorded from the area around Ottawa where they are common, and the White Bass is mapped for Ottawa where it does not occur. Evidently, the maps must be taken as a general guide to distribution and cannot always be used locally, where most students and naturalists work.

At the end of the book there is an appendix of line drawings of the larval stages of some of the fish of the Great Lakes region. This book is geared towards the identification of adult fish and any inquiries as to the identification of larvae are directed to consult other works. The index includes species names, common names and some key words. No glossary is provided though its presence would be ideal. While a section on anatomy is given at the beginning, it is not useful as a quick reference, nor is it complete (for example, adipose and falcate are not explained in the book, nor are markings well described). The book ends with a series of 32 colour plates with several species per plate, which are generally useful to flip through to locate a species that you are already somewhat familiar with, although many of the colours are inaccurate making identification by a beginner difficult.

The page numbering system is a little confusing, sometimes at the bottom of the page, sometimes at the top, sometimes missing and easily confused with

the numbering system for species. There are also some errors of omission and commission. It is noted that scales are not used for ageing mudminnows but does not explain why. The number of lamprey species is given as about two dozen (the same as in the 1964 edition) but this number has increased to about 34 since then. Some scientific names are given as a trinomial; e.g., *Semotilus atromaculatus atromaculatus,* but no other subspecies are mentioned which makes this extensive name unnecessary.

The list of families provided includes native fish only, so to get a comprehensive count of all the different genera and species in the Great Lakes region you would have to look through the entire book. Also, upon comparing the present list to the list provided in the 1964 edition, the latter includes all fish, not just native species. It is therefore not possible, without great effort, to find out how many new native fish have been discovered in the past forty years. There have also been many name changes that have occurred since the last edition was published. *Entosphenus lamotteni* has now become *Lampetra appendix*, *Lepisosteus productus* has become *Lepisosteus oculatus*, and *Pomolobus pseudoharengus* has become *Alosa pseudoharengus*, to name a few.

Some of the criticisms of this book mentioned here could be addressed by an on-line version. This book must be small and therefore concise for use in the field and laboratory. An on-line version could have larger maps (updated as new information or corrections are noted), colour photographs of live fish which would be of use to field workers, keys segmented by lake or country (most work is done locally, a worker in eastern Ontario would not find the same suite of species as a worker in Illinois), larger illustrations of key characters, key characters embedded in the key for easier reference, new species could be added as discovered, and keys to larval fish developed.

This book is a great tool for use in the lab or field by beginners and professionals alike. With some use it will lay open flat, preventing the loss of place while your hands are busy working on the fish. The positive reputation of this book as *the* book for Great Lakes region fishes is long standing and will only increase with time.

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Seabirds and Atlantic Canada's Ship-Source Oil Pollution

By F. Wiese. 2002. World Wildlife Fund, 245 Eglinton Avenue East, Suite 410, Toronto, Ontario M4P 3J1 Canada. 82 pages.

The public seems to have a love-hate relationship with oil. Oil allows for high salaries and contributes to civilisation, but it also can create severe pollution. As this report shows well, chronic offshore oil ranks among the most severe pollution problems in the world.

"Many people consider Canada to be one of the leading nations in environmental conservation in the world". However, the still conservative estimate of 300 000 dead Canadian seabirds due to chronic oil pollution and presented in this report is shocking; to say the least. Besides a seabird population issue this also a major animal care issue: over 300 000 animal individuals are suffering and are dying a gruesome death. As this informative report emphasizes, for each oiled seabird found in Newfoundland one can assume that at least 10 more have died.

Together with several individuals devoted to the issue of marine and oil pollution, author Dr. F. Wiese studied seabirds and their oil-related mortality for many years. His report on chronic offshore oil pollution is structured in two parts: The Problem (11 chapters) and The Solution (8 chapters); four appendices, a list of abbreviations and some references are also given. Half of the report deals with OSIRs (Oil Spill Intelligence Reports 1997-2000), presented in Appendix 4. OSIRs are only accessible for few signed-up members, and it is great that this report provides the wider public with an opportunity to access this information. Besides reporting baseline numbers of seabird mortalities and oil pollution incidents, other highlights of this document are presented to a wide audience dealing with ocean modelling, detectabilities of oiled birds on a beach, drift block experiments and emphasizing how important such methods are to address the chronic offshore oil pollution efficiently and in accurate terms.

"Most of those in the marine industry carry out their operations in a safe and environmentally responsible manner." This statement is somewhat in contrast to the fact that oiled birds keep washing up on shorelines worldwide which suggests that national legislation and international conventions and guidelines are not being followed or that they are inefficient. "The illegal discharge of oil from ships into the world's oceans is a global problem that affects the entire marine ecosystem". This calls for a global oiled bird survey; e.g., citizen- and volunteer-based marine and beach surveys.

From this nice report it becomes quickly obvious that the history and track-record of chronic oil pollution, a by-product of the current civilisation, is not an environmental success story. Instead, the current progress for trying to keep the (marine) environment clean presents more of an international embarrassment. It is still difficult to understand why the "burden of proof" for chronic oil pollution is not on the industry side. After reading this report and its seabird facts one cannot deny that oil pollution equals environmental massmurder.

It is correct that the Canadian legislation extends the enforcement of shipping, environmental, and

wildlife law to the 200-mile exclusive economic zone. However, some federal legal decisions have restricted these laws to the 12-nautical-mile territorial zone. Offshore pollution monitoring flights are made by Transport Canada and by the Canadian Coastguard; the Department of National Defence and Department of Fisheries and Oceans are encouraged as well. Although the Canadian Shipping Act, the Migratory Bird Convention Act, the Canadian Environmental Protection Act and the Fisheries Act deal with oil pollution issues, suspected ships have rarely been turned back to a Canadian port for further investigations. Only the Migratory Bird Convention Act protects migratory seabirds from oil-related offences; but so far, only five vessels were charged. Knowing that approximately 2500 offshore oil spills are reported per year in Atlantic Canada, one gets quickly an idea of the issue. Obviously, pollution pays ... and as the report convincingly shows, the pollutor gets almost awarded due to the competitive business advantage when not punished. Atlantic Canada is simply the cheapest place to dump bilge oil on the Great Circle route between North Atlantic and Europe. No doubt, the enforcement needs to be stronger in Canada, higher fines are required, and on board disposal facilities, increased monitoring, increased awareness and other measures are necessary. Even the European Union uses RADARDSAT (SAR), a satellite image product from Canada, in order to trace and to monitor offshore oil pollution.

As Wiese's WWF report presents, Canada does not really have a national standard for an EDA (Environmental Damage Assessment). It is surprising that the exact number on "how many seabirds are really oiled" is hard to get and not available with high accuracy; accurate numbers seem not to play a role in the legal decision and discussion even! Perhaps court fines should consider a price per oiled seabird, and thus could change the current dilemma?!

This document reports that approximately 40 million pelagic seabirds reside during the year on the Grand Banks off Newfoundland. However, some of the presented numbers are puzzling and might cause confusion for the informed Naturalist. It was reported earlier that over 200 000 Thick-billed murres are killed annually during the Murre hunt off Newfoundland. Now, chronical oil pollution is even added, but breeding Thick-billed Murres in the Canadian Arctic – the seabird species believed to be affected the most by chronic oil pollution – does not show a significantly declining population trend at all. Are Canadian seabirds sensitive indicators of the marine environment ? Or are birds from other areas in the world and being present in Canadian waters, such as Greenland's Thick-billed Murres and Manx Shearwaters from England (both populations are known to be declining), better indicators ? More research is required. Some other confusion might arise from the presented population numbers of wintering Eastern Harlequin Ducks, and that no direct relationship is known to exist between the amount of oil spilled and the numbers of seabirds killed. For my taste, some key references such as J. Burger's 1997 book on "Oil Spills" would have been a great addition. Of interest might also be the seabird oil pollution work in British Columbia by A. Burger, the Festucca Oil Spill Trust Fund and the Provincial Government's work. Globally speaking, it might be interesting for the reader to learn how Norway, a country with major offshore oil resources and with a very long coastline and huge seabird resources, deals with chronic oil pollution! Perhaps it would also be informative to have a list of all known oil vessel accidents in Canadian waters.

However, this informative report provides many important details and baseline information on the sligthly overlooked but very relevant chronic oil pollution topic in the offshore waters of Eastern Canada. It focuses on seabirds; but many other species and the entire ecosystem suffer from oil pollution, too. "Chronic oil pollution is an international problem whose solution requires national and international effort".

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Spiders of Australia: An Introduction to their Classification, Biology and Distribution

By T. J. Hawkeswood, 2003. Pensoft Publishers, Geo Milev Street 13a, 1111 Sofia, Bulgaria. 264 pages. EURO 19.95 paper, 34.95 cloth

The past few decades have seen the production of a considerable number of landmark volumes on the natural history of regional spider faunas. Volumes by Dippenaar-Schoeman and Jocqué (1997), Song *et al.* (1999), Ubick et al. (2005) among others have set a high standard for concise, useful, in-depth coverage of regional faunas. With this in mind, I readily agreed to review *Spiders of Australia: an Introduction to their Classification, Biology and Distribution*.

I tried, I really did try, to find good things to say about this book. Certainly the dust cover of this volume, with its border of 24 colour images of various Australian spiders surrounding an anthropomorphic photograph of the front end of an immature male deinopid spider (looking as charmingly pugilistic as only an immature male can), promises an interesting and engaging piece of work. Unfortunately, as they say, you can't judge a book by its cover.

The content of *Spiders of Australia* falls far short of fulfilling the promise of either the cover or title. Interesting observations on the natural history of a variety

of relatively common and fairly well known spiders from Oz are marred by errors of fact and/or presentation on nearly every page. One is left with the impression that the well-meaning author has little professional knowledge of spiders and that the text never received professional content or copy editing.

This volume commences with a brief preface followed by several short introductory chapters covering spider morphology, natural history, classification and other general topics. Anyone with more than basic knowledge of spiders will find much to criticize or question within these pages. For instance, we are presented with the following dubious "facts."

- Spiders are important in controlling mosquito populations. In reality, fish, birds and various other organisms are vastly more important for mosquito control than are spiders.
- There are about 20 000 and 1800 spider species in the world and Australia respectively. The actual figures are closer to 40 000 (Platnick 2006) and 3300 (R. J. Raven, Queensland Museum, personal communications).
- Male and female spider genitalia fit together like a "lock and key mechanism." Wrong! Spider genitalia are one of the best known examples of rapid evolution likely resulting from sexual selection by female choice (Eberhard 1985).
- Palps of male spiders are "hollowed out" to hold sperm. An insult to male spiders everywhere! Mature male spiders are unique in (and defined by) their possession of palps bizarrely modified into complex sperm storage and transfer organs.
- A considerable number of Australian spiders pose "a serious threat to humans in Australia." Wrong! Among Australian spiders, only widows (*Latrodectus hasselti*) and a couple of funnel-web spiders (*Atrax* and *Hadronyche* spp.) pose any threat and true bites from these spiders are exceedingly rare (Isbister 2004, Isbister and Gray 2002). Australians are better off spending their paranoia time worrying about being hit by lightning.

Things don't get much better in the subsequent chapter ("Species described in this book") which forms the bulk of the text. Approximately 125 pages discuss 141 species in 29 families (or about 4 and a little more than 30% of the currently recognized species and families represented in Oz). Each family section lists the number of Australian and world species in the family and describes the general appearance, life history, and behaviour of one or more exemplar species. Unfortunately, the families are organized in a confusing quasi-phylogenetic manner, the species statistics are often erroneous, the descriptive information is largely useless for identification purposes, other information is often misleading or erroneous, and the vast majority of the unique and truly wonderful Oz spider fauna is ignored.

For instance, consider the author's treatment of the family Pholcidae. Australian genera and species are listed as 9 and "about 12" and the cosmopolitan *Pholcus phalangioides* is the token exemplar. The author references the most recent taxonomic work summarizing the Oz pholcid fauna (Huber 2001) but missed the fact that this work records 14 genera and nearly 80 species (and still counting). Well, okay, I sometimes have trouble with math, too. But in such a book I expect to be introduced to truly Australian pholcids instead of to an already well-known species found throughout the world. The section is further marred with factual and typographical errors. Similar problems surface in the treatment of other families. As well, erroneous medical "information" is regularly trundled forward – e.g. under Lamponidae, almost entirely an Australian family, discussion of the life and times of *Queenvic piccadilly* would be vastly preferable to reiteration of the discredited medical mythology surrounding *Lampona cylindrata*.

A short glossary of slightly less that 100 entries follows the "Species described ..." chapter. Explanations are generally clear but one wonders why such terms as anus, bark, and solitary warrant entries but mygalomorph does not. Nearly 30 pages of references conclude the text. There is an annotated section on general texts on Australian spiders and fairly complete and up-to-date scientific references are presented for each family. In spite of considerable repetition [e.g. Rainbow (1911) appears no less than 29 times] the references are easily the most useful part of the entire book.

The book finishes with a set of 139 photographic plates and 27 paintings of the main species discussed in the text, arranged 3 to a page. Some of the photographs are quite nice illustrations (e.g., plate 5 *Deinopis subrufa*, the cover boy mentioned earlier, and plate 16 *Lycosa bicolor*, also featured on the cover as one of the border images). The paintings are without exception unexceptional – two-dimensional, flatly coloured, and crudely rendered.

In summary, if you are looking for an interesting decorative wall piece, frame the cover and recycle the rest (maybe keep the references section). If seriously curious about general spider biology and classification, spend your money on Levi and Levi (1968) or Foelix (1996). For specific information on the spiders of Oz, buy Murphy and Murphy's (2000) treatise on southeast Asian spiders – it does a much better job of introducing the fauna than does *Spiders of Australia*

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Annotated Bibliography of Quaternary Vertebrates of Northern North America With Radiocarbon Dates

Edited by C. R. Harington. 2005. University of Toronto Press, 10 St. Mary Street Suite 700, Toronto, Ontario M5T 1R5 Canada. 539 pages. $150.00 CDN.

Bibliographies have proven an essential tool in any historical based research, yet are often underrated. In paleontology, specifically vertebrate paleontology, many have relied upon *Bibliography of Fossil Vertebrates Exclusive of North America 1509-1927* (Romer et al., 1962), and *Bibliography of Fossil Vertebrates* (BFV) (produced by the Society of Vertebrate Paleontology), and their earlier versions. The BFV, however, is no longer updated. Taxon-oriented bibliographies are also produced, like Crossman and Casselman's (1987) annotated bibliography of *Esox lucius*; and theme oriented bibliographies like Tokaryk et al. (1992) annotated bibliography of the Cretaceous-Tertiary extinction event. Without continued maintenance, these, however, are quickly dated.

Harington's *Annotated Bibliography of Quaternary Vertebrates of Northern North America – with Radiocarbon Dates* is a recent contribution to the stacks of paleontological resources. This volume contains 1347 citations (in 328 pages) from 1748 to 2000, containing descriptions or notices of fauna from 2 million to 5000 years ago. The region is inclusive of Alaska, Greenland, and Canada.

The annotation is of sufficient depth when warranted and the reader will note the brevity given to many of the pre-20th century articles as these themselves lack sufficient depth. The indexing, always a vital tool in bibliographic construction, is subdivided into five sections: scientific names; common names; localities and stratigraphic terms; personal names and institutions; and of a general index. This latter section, always constrained by the subjective nature of its composer, can be relied upon for consistency simply for the fact of Harington's long time standing in Quaternary paleontological research, which is beyond reproach.

The facet that will make Harington's work not only stand out but retain a longer shelf life is the 138 additional pages devoted to radiocarbon dates associated with taxa. This extended table, all the more important in Quaternary paleontology than in any other paleontological subdivision, includes institutions responsible for the results, and published references. Collectively, this volume will provide a long lasting reference for students and professionals of Quaternary life in North America.

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White as a Ghost: Winter Ticks and Moose

By Bill Samuel. 2004. Federation of Alberta Naturalists, 11759 – Groat Road, Edmonton, Alberta, T5M 3K6 Canada. 100 pages. $ 24.95.

Parasites are a fascinating study. They are able to adapt and evolve in order to survive in or on their hosts, but usually will not kill their hosts. Books about parasites are not often found in a public library, but White as a Ghost would be a good addition. It has a large format, 28 cm × 23 cm, with excellent photographs illustrating the text, but is not a coffee table book. It is intended to give trappers, Fish and Wildlife officers, hunters, farmers and biologists the knowledge they need to understand and recognize the life cycle of the tick which causes Ghost Moose: *Dermacentor albipictus*. Wilderness campers, more than the general public, are most likely to come across Ghost Moose.

Dr. Samuel is a parasitologist who studies parasites of deer, Elk and Moose and in particular the tick which causes Ghost Moose. The tick is widespread

and is found throughout the North American ranges of deer, Elk and Moose except the far north. Deer and Elk seem able to co-exist with this parasite, and they remove most of the ticks by efficient grooming before they can do much harm. But Moose are less capable of combating an infestation. The eggs of *D. albipictus* are laid on vegetation in the spring, and from September to November the hatched larvae climb up the vegetation and attach themselves to a passing animal. After November the larvae left on the ground die. Once attached to Moose, larvae feed on Moose blood before becoming nymphs; the nymphs are dormant until February, then moult and become adult ticks. All three stages depend on blood to survive, but it is in March and April that their feeding causes the Moose to become so weakened by loss of blood that some can die. The tick bites can also introduce other pathogens into the host so that there may be multiple causes for death. After May, the female ticks drop off the host, lay their eggs in sheltered places and the cycle starts again. The irritation of the bites make the Moose groom incessantly, mostly with its tongue, which breaks off the ends of the coat hair leaving only the short undercoat exposed. This is grey-white and gives the Moose the typical "ghost" appearance. Licking can also break the skin, allowing easier access for the ticks. A serious infestation will create large open areas of bleeding skin and consequent debilitation.

Moose populations in Canada are stable, but when a local population increases, the young in particular start the winter under-nourished and more susceptible to disease. Then there can be a serious die-off in March and April due to tick infestation. There were major die-offs of up to 50% of the population in some areas in 1991 (Minnesota), 1999 (six provinces, British Columbia the worst), and 2002 (eastern provinces and the prairies). Some dead Moose have carried more than 500 000 ticks. Effective prevention is difficult but Dr. Samuel suggests that a possible solution would be to cull Moose where there is a population build up, thus reducing the demand on the available food sources. Experiments have shown that Moose can detect and avoid tick-infested vegetation but if food is scarce, they will eat it.

There are chapters on the life cycle of the tick, how they are adapted to attack Moose, their invasive characteristics and behavioural strategies used by Moose to evade the ticks. The book is attractively illustrated and for light relief, there are good puns on the word "tick": e.g., characteris-ticks, and a poem or two. Knowing more about the life cycle of the tick and its serious effects on Moose populations should be of value to anyone travelling or working in the areas where moose are found.

The Federation of Alberta Naturalists has published several natural history books, and their Atlas of Breeding Birds of Alberta is a best seller. They commissioned Dr. Samuel to write Ghost Moose which is an interesting and serious book about a wildlife disease. It makes absorbing reading and describes an aspect of wildlife we seldom hear about.

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Lewis and Clark on the Great Plains: A Natural History

By Paul A. Johnsgard. Bison Books, University of Nebraska Press, 1111 Lincoln Mall, Lincoln, Nebraska 68588-0630 USA. 143 pages, $18.28.

One of the most profound expeditions in American history and culture was of the Lewis and Clark adventures, 1803-1806. Led by Meriwether Lewis (1774-1809) and William Clark (1770-1838), the expedition was one of the first systematic surveys of the natural resources and natural history of the American west. And as such, the published record since the early 19th century pertaining to these treks is voluminous. From narratives and journals (e.g., Moulton 1983-2002), their place in history, and their experiences with natural history (Cutright 1969), all raise Lewis and Clark to American cultural icons.

Johnsgard's *Lewis and Clark on the Great Plains* adds to this list but should not be considered a significant contribution to the histrionics of the expedition and what it meant. The author's contribution is more in line with a combination field guide / history lesson of the wildlife encountered by Lewis and Clark's group. Following a brief introduction, the book is chaptered by contemporary States with regional maps outlining expeditionary routes. This template is essential in understanding the chronology as the expedition at times retraced their steps in a single season, if not over the course of the expedition's history.

The bulk of the content is a listing of the flora and fauna (complimented with scientific and common names). In user friendly manner Johnsgard provides a concise synopsis of the taxa followed by shorter notations as to the encounters with the expeditionary force. The Western Hognose Snake (*Heterodon nasicus*) for example, was likely found and described on July 23, 1805 near Townsend, Montana, prior to the formal erection of the species in 1852 (Baird and Girard 1852). Based on his description, "Lewis should be credited" Johnsgard contends, "with the discovery of the species" (page 97).

Visual support for the descriptions come from the authors own line drawings, 39 in all. Simple in vision yet detailed, collectively with the body of text, make this little volume an added historical perspective to viewing nature as it once was, 200 years ago.

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Baird, S. F., and **C. F. Girard.** 1852. Reptiles. Pages 336-353 *in* Exploration and Survey of the Valley of the Great Salt Lake of Utah, including a reconnaissance of a new rout through the Rocky

Mountains. *Edited by* H. Stansbury. Lippencott, Grambo, and Company, Philadelphia, 487 pages.

Moulton, G. E. Editor. 1983-2001. The Journals of Lewis and Clark Expedition. 13 volumes. University of Nebraska Press, Lincoln.

Cutright, P. R. 1969 [1989]. Lewis and Clark: Pioneering Naturalists. [Reprint]. University of Nebraska Press, Lincoln.

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Waterfowl of Eastern North America

By Chris G. Earley. 2005. Firefly Books: Buffalo, New York; and 3680 Victoria Park Avenue, Toronto, Ontario M2H 3K1 Canada. 158 pages. $19.95 Paper.

This attractive bird identification book is clearly aimed at the beginner birder. It is the fourth in a series of similar books by the same author and publisher. Earley properly cautions new birders about hasty and uncertain judgments in the often perplexing task of bird identification.

A cursory review of this handsomely printed, full-color book, measuring 5½" (14.0 cm) by 8½" (21.6 cm) by ½" (1.3 cm), makes a favorable first impression. In particular, the photographs of individual birds, usually in nuptial plumage, on the water and flying, and when used in comparison with look-alike birds, are excellent. Two pages are usually devoted to each species, including photographs, a small range map, and brief text mostly descriptive of non-breeding season plumages. Two to four sentences tell a bit about each species and a sentence or two under "Nature Notes" provides additional eclectic, often trivial information.

Unfortunately, my initial favorable impressions soon changed. First, the title is a misnomer. A substantial number of the species included are not waterfowl as defined by the AOU checklist, which the author references. Rather, the author re-defines waterfowl to include other "ducklike birds", such as some species of loons, grebes, pelicans, cormorants, rails, and gallinules. Attention to these species comprises about a quarter of the pages accorded the true waterfowl.

North America and Eastern North America are not defined. By AOU definition the mainland of North America extends south through Panama, including associated islands. Consequently, some native North American species are missing. On the other hand, several exotic or species of rare or irregular occurrence are addressed (e.g., Mute Swan, Barnacle Goose, Garganey, Tufted Duck, and Smew). Oddly, four full pages are devoted to each of three species rarely (unlikely ever to be) seen by many birders (the King and Common eiders and the Long-tailed Duck); but the commonest North American duck, the Mallard, receives only two pages.

Other problems arise. The range maps are too small, especially for coastal species when the pale yellow representing winter range is cast against the light gray background. The map depicting the wintering range of the Blue-winged Teal (page 47) as including northeastern Argentina, Paraguay, Uraguay and extreme southern Brazil is incorrect. Upon close examination, the unnatural, vertically-flying shoveler (page 9) is certainly a cropped view of the horizontally-flying bird depicted on page 14 with the photo reversed and rotated 90 degrees. The photograph of a flying male Common Merganser (page 147) is mis-labeled as a Hooded Merganser.

The two-page chart titled "Seasonal Status of Waterfowl" (pages 16-17) is based solely on observations at Point Pelee National Park [Ontario]. While perhaps useful in showing relative species abundance and temporal distribution in the Great Lakes region, it has questionable relevance elsewhere.

"What can I do to help waterfowl?" (pages 130-131). is largely about nesting boxes. Only a half-dozen or so waterfowl utilize such structures. Nothing is said about North American waterfowl being protected by international treaties, federal laws, and laws and regulations of the various states and provinces.

The list of references (pages 154-155) is peculiar. Some entries are outdated (e.g., Studer, 1881) or are primarily of works of art (e.g., Brasher 1962, Lansdowne 1980). While the definitive *AOU The Birds of North America* monographs (Poole and Gill, eds.) are noted, their scientific excellence, content, and format are undescribed and their general unavailability, except in larger libraries, is unmentioned.

A number of important waterfowl references are overlooked (e.g., Delacour's four-volume *The Waterfowl of the World*; Palmer's *Handbook of North American Birds*, Volumes 2 and 3, Waterfowl; Volume 1 (Ostrich to Ducks) of the magnificent *Handbook of the Birds of the World*, edited by del Hoyo, Elliott, and Sargatal; and even the early but enduring John C. Phillips' four-volume opus, *A Natural History of the Ducks*. Despite the attention given wood ducks and nesting boxes, Frank Bellrose's splendid monograph (*Ecology and Management of the Wood Duck*) is likewise missing. All of these basic references could easily have been accommodated in the large blank space on page 155.

Much of what the novice birder learns in this book will have to be forgotten should his early interest in birding lead him forward. Perhaps the concerns and errors noted above, and others unexpressed, will be corrected in a reprinting. In the meantime one would be wiser to spend a few more dollars for one of several time-tested, authoritative field guides listed among the author's references.

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Wolves: Behavior, Ecology, and Conservation

Edited by D. Mech and L. Boitani. 2003. University of Chicago Press, 5801 Ellis Avenue, Chicago, Illinois, 60637 USA. xvii + 448 pages, U.S. $49

In 1961, wolf biologist Douglas Pimlott wrote: "The wolf poses one of the most important conservation questions of our time. Will the species still exist when the twentieth century passes into history?"

Pimlott, if he were alive today, would be amazed and heartened by *Wolves: Behavior, Ecology, and Conservation* by L. D. Mech and L. Boitani because not only does it describe evidence of a "turn around" for the species that occurred in recent decades, but provides an encyclopaedia of scientific information about the wolf that has come from a remarkable amount of research over the past 40 years.

This book replaces one by David Mech written in 1970. However, this "update" is a much expanded, 22-authored, 448 page tome that provides one of the most extensive descriptions of the ecology of any mammal species in the world. The Table of Contents provides evidence of the book's depth, with chapters on: wolf social ecology; behaviour; communication; wolf-prey relations; wolf physiology; genetics; evolution and taxonomy; interactions with non-prey; restoration of the red wolf; wolves and humans; wolf conservation and recovery.

This is a book that you should read in selected chapters, rather than from cover to cover. There is too much detail to absorb, and although mostly written clearly, the style is fully referenced science. The book is well indexed, and brings together research conclusions on any conceivable topic related to wolves, very useful either for the interested person or the biologist.

The intent of the book, according to the editors, is to counter the "myth and legend, forklore and fairy tale" that has, and continues, to surround the species, by presenting a scientific view of the animal. The underlying assumption is that this scientific understanding will result in support for wise management of the expanded wolf populations that now exist in many places in the world. A more poetic reason for the book is given by physiologist Terry Kreeger: "Physiologically, we know a great deal about the wolf, although we still have much to learn. But why should we continue to study the wolf? Some people curse the animal; others deify it. As scientists study it, we may be able to blunt these extremes and place the wolf in proper perspective. Wolves tend to roughen the edges of a world being smoothed by human hands. For many of us, that is good reason to learn what we can about them, inside and out, and certainly good reason to work for their conservation."

Some chapters are difficult, particularly those addressing wolf taxonomy and genetics, because the data from research are themselves confusing, contradictory or only tentative. Both fields have been fraught with "re-interpretations," sometimes by the same researchers, and consensus on what constitutes adequate evidence is unclear. For example, in the genetics chapter is a statement that parent-offspring relationships can be determined by examining nuclear DNA at as little as 10 microsatellite loci, whereas work done in association with our Algonquin wolf studies showed that as many as 15 loci were needed to avoid mistakes. These chapters leave their respective topics in chaos; hopefully, analytical methods soon will improve.

All other chapters are more readable and, because of the wealth of data, lead to more intruiging descriptions of the lives of wolves. Portrayed here are images of the wolf as a highly adaptable and intelligent species, one with a set of biological limits and norms, but with the flexibility to exercise a great deal of individual choice, the key to its success.

Human-wolf relationships are chronicled through the ages, right up to modern attitudes and their consequence for the future of the species. In a final chapter, Mech and Boitani reflect on the need to shift our perspectives on how to manage wolves from one of past "trench warfare" between people with different attitudes, to some new, more moderate paradigm that accepts the wolf with human imposed limits on population size, particularly in human-altered environments where it has been shown capable of surviving. Missing, however, is recognition of the importance of maintaining at least some areas as a crucible of natural selective forces surrounding the species – the very forces out of which the species evolved – rather than being content with the imposition of human modified environments and human control. There is still more to achieve before we congratulate ourselves in saving the real "wild" wolf in real intact wilderness.

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BOTANY

Rendezvous with the Wild: The Boreal Forest

Edited by James Raffan, 2004. The Boston Mills Press, 132 Main Street, Erin, Ontario N0B 1T0 Canada. 192 pages, $49.95 Cloth.

Named after the Greek god of the northwind, Boreas, the boreal forests of the world carpet the northern circumpolar reaches. St retching across Canada from New-

foundland to the Yukon, the boreal forest reaches into Alaska, through the vastness of Russia and into the Nordic countries of Scandinavia. Forests of coniferous black spruce, white spruce, balsam fir, jack pine, and tamarack, interspersed with deciduous white birch, aspens, willows and alders dominate the boreal scene.

Canada's boreal forests are of national, and indeed, global significance. Approximately 40% of the globe's boreal forests lie within Canada's boundaries. Fifty-eight percent of Canada's landmass is boreal forest that includes over 90% of the country's remaining large, intact forest landscapes or 25% of the globe's intact forests. Ecological values include prime habitat for many species of wildlife (including 75 percent of the continent's waterfowl), vast areas of lakes, rivers and wetlands and globally significant storage of carbon.

Canadian forests, especially the boreal forest, have long played a key role in the national economy. In 2003 alone, forest products contributed almost $30 billion to Canada's $46 billion trade balance. Canada is the world's second largest producer of wood pulp and the world's largest producer of newsprint. Direct forest industry employment totaled 376 300 workers for 2003. Much of this economic activity is directly related to the boreal forest that acts as the economic foundation for many communities across the country.

Given the economic and ecological significance of Canada's boreal forest, it is small wonder that people are becoming increasingly concerned about the long-term sustainability of this continental biome. *Rendezvous with the Wild* is the latest in a series of books, articles and media features on the future of the boreal forest. It tells the story of the Boreal Rendezvous, a series of canoe trips taken in the summer of 2003 on ten Canadian boreal rivers from the Wind River in the Yukon to the Moisie in Quebec.

The canoe trips were a vision of the Canadian Parks and Wilderness Society (CPAWS) in collaboration with the David Suzuki Foundation, the Canadian Boreal Initiative, and Mountain Equipment Co-op. They sought ways that would help shift our relationship with the boreal forest from one of accelerating large-scale, industrial fragmentation and transformation, to one that focused more on boreal forest conservation and viable, sustainable development.

Edited by the well-known Canadian author and avid canoeist James Raffan, *Rendezvous with the Wild* is an enticing collage of photography, art, journal entries, essays, poems, musings and prayers from many of the canoe trip participants. The variety of entries is marked by the diversity of contributors. Over 70 people including Native elders, conservationists, television celebrities, scientists, photographers, poets, academics, canoe builders, and musicians contributed their voice and creativity to this marvelous tribute to the mystery and attraction of the boreal forest.

As Raffan notes in his opening essay, this is not a book about the boreal forest, but rather a book in response to the boreal forest. The canoe trips and canoeing act as constant themes weaving their way through the rich and varied fare. The photography is splendid and the book's layout a delight to the senses. The reader is carried along the current of the river with boreal vistas provided by the many witnesses offered by the book. Of particular strength throughout the book is the vision and witness of the First Nations to their boreal forest home.

The French philosopher Blais Pascal once remarked that the human heart has reasons of which the mind knows little. In boreal forest conservation issues, the environmental community often takes refuge in the technical, scientific dimensions of any particular boreal forest issue. This is essential and necessary. However, sole attention to the technical dimension fails to tap the depths of energy that can be attributed to the multidimensional human experience of the boreal forest. This human "emotional" experience is often dismissed as simply a "subjective," private experience that cannot be accepted on par with so-called "objective" scientific knowledge of any particular issue. *Rendezvous with the Wild* dispels such dualistic thinking and attempt to legitimize the direct human experience of the boreal forest as a powerful force that may energize action on behalf of forest conservation.

Rendezvous with the Wild begins and ends with a prayer by William Commanda, an Algonquin elder from Maniwaki and honorary elder of the CPAWS Boreal Program. The book is thus bounded by the spiritual, by due attention to the human experience of the boreal forest. You will have to look elsewhere for material on the boreal forest, on its ecology, on the impact of industrial activity, or the development of boreal forest policy. *Rendezvous with the Wild* attends to other data, to the inner data of human consciousness vis-à-vis the boreal forest. I have no doubt that if such data is not seriously considered, then conservation and sustainable development of Canada's boreal forests will remain a dream – forever.

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ENVIRONMENT

The Earth's Blanket: Traditional Teachings for Sustainable Living

By Nancy J. Turner. 2005. University of Washington Press, P.O. Box 50096, Seattle, Washington 98145-5096 USA. 298 pages, U.S. $29.95.

Nancy Turner's book, *The Earth's Blanket* is a thorough treatise on indigenous peoples' relationships with the environment, and has as its goal to demon-

strate and better understand alternative ways of viewing the world. Underlying the theme is the concern that the rich environmental knowledge that sustains the earth's ecosystems is being lost at a time of great environmental devastation. It is well researched, well supported with references and source notes, and cites numerous examples to substantiate all claims.

The central thesis revolves around the concept of the earth's blanket, which is a metaphor used by the Nlaka'pmx of the southern interior of BC, to describe the plants that cover the earth; if removed will cause the earth to be "angry" and to "weep". Turner weaves the theme of the reciprocal relationship that humans have with their environments throughout the eight chapters. The reader moves through discussions of wealth and value in a changing world, a kincentric approach to nature, honouring nature through ceremony and ritual, to land stewardship, all richly illustrated with stories of First peoples and historical accounts (from the 1800s onwards from the journals of Simon Fraser) of Indian agents, anthropologists and early European travelers.

An ethnobotanist for over 30 years and as a non-indigenous academic, Turner skillfully combines the perspectives of indigenous peoples: chiefs, friends, Elders, ethnobotanists, in several communities in British Columbia, with some examples from indigenous communities in other parts of the world (i.e. Sierra Terrahumara, in Mexico). Turner has fluency with First Nations peoples and issues in British Columbia and through developing trust and friendship, has become close to special and profound relationships with earths' offerings. Turner provides several traditional stories, ceremonies and rituals that are "situated", connected to the history and geography of the region and thus connects people to place. Stories also demonstrate how knowledge and understanding of the environment is relational – that the plants, animals and other features are imbued with human qualities, so that humans are not viewed as separate and outside ecosystems.

Several important issues emerge throughout the book that tie together the loss of cultures and environmental destruction: the importance of language is mentioned several times, in that language is a reservoir of traditional knowledge, culture and connections to the landscape. Loss of language severs that connection. The consequences of environmental destruction are poignantly described using several species, with salmon a recurring example throughout the book. Salmon is a strong marker of cultural identity for British Columbia First Nations and is a thread throughout the book that weaves together origin stories with scientific understandings of salmon ecology. Turner provides details on how to prepare salmon and chronicles the demise of salmon stock and the effect this has on communities that depend on the catch. One Secwepemc story about salmon migration helps children learn that salmon are to be respected and admired. Other key species that are indicators of ecological decline are the Bitterroot (*Lewisia rediviva*) used by the Nlaka'pmx peoples, numerous edible berries and abalone.

In Chapter 7, "Everything is One", Turner ties together the several different themes that focus on human's interdependence with the environment. The interconnections that are so vital are expressed in the story of the Xaxl'ep people who live at Fountain, a small settlement near the Fraser River, where "Everything in their territory is connected to them and if part of it is lost the Xaxl'ep lose part of themselves." This makes the point that when habitat and resources are taken away, people lose the knowledge associated with that place and that resource.

Towards the end of the book, Turner introduces scientific concepts such resilience, complex systems, adaptive management and ecosystem based management to bring together the multi-faceted human-ecosystem relationship and how we can live sustainably. There are stories of hope and ideas for a sustainable future. For example, the Stó:lô people of the Fraser valley are revitalizing their language and cultural heritage after the drainage of the Sumas Lake in the 1920s and the subsequent loss of traditional resources, and means of transportation for the Stó:lô people. The Tmix^{w} research project of the Nlaka'pmx people encourages developers to integrate traditional knowledge with land management to foster a sustainable land ethic. Turner suggests three criteria for positive change and eight concepts for ecocultural restoration and urges us to continue to be optimistic despite the level of environmental destruction that we are witnessing globally.

If there are any shortcomings to this book, they are few. At times, it is difficult to delineate the chapters as several of them overlap and appear repetitive. While Turner is meticulous in providing both scientific and indigenous/local language names for all species mentioned, the scientific name is sometimes provided more than once, when once would have been sufficient. Also, Turner does not address changes in attitudes towards the environment by First Nations – there are often difficult trade offs to be made when economic benefits seem to outweigh traditional teachings of respect and environmental conservation. Attitude change occurs within communities as values shift – addressing what is to be done about the loss of sense of responsibility for stewardship is a difficult issue. In all, however, the book provides important lessons on First Nations stewardship and promises of positive change if we all just listen.

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Greenpeace: How a Group of Journalists, Ecologists and Visionaries Changed the World

By R. Weyler. 2004. Raincoast Books, 9050 Shaughnessy Street, Vancouver, British Columbia, V6P 6E5 Canada. 574 pages. $25.95.

Rex Weyler has released an honest, informative, and politically motivating history of the first nine years of the Greenpeace movement, charting its course from its inception in a Vancouver living room in 1970 to its official internationalization in an Amsterdam pub in 1979. While others have written histories of this now widely-studied movement, Weyler's is of a different sort: he is an insider to the group, having been a Greenpeace activist since 1974, and knows its key players better than most. He relates individual motivations and personalities, and shares both the bitter disputes between factions of the movement and the eco-political victories celebrated over pints of beer. Weyler divides his study into three sections: War and Peace, All Sentient Beings, and Political Ecology. Throughout, he relates the growth of the movement and its increasing lens of awareness in a style that is clear and captivating, teaching readers about the commitments of the movement and winning new environmental activists as he details the group's adventures.

Weyler begins by locating the global climate of 1970, as seen from the west coast of Canada. War in Vietnam continued to rage, and American draft dodgers were fleeing to Canada by the thousand. The public outcry against war built throughout the 1960s, and the ever-quickening pace of the international arms race daily increased the number of anti-war activists. Meanwhile, the world's superpowers invested billions to stay in military advance of competing nations. Nuclear bombs were dropped at a rate of one per week, often with total disregard to populations neighbouring test sites. These nuclear blasts were contaminating entire cities with fallout, and the toxic Strontium-90, a by-product of the nuclear tests, was spread globally through the atmosphere. Most frightening, perhaps, were the questions surrounding the bombs that continued to be tested with ever-increasing rapidity. In the race to produce the biggest and strongest atomic bomb, each superpower allowed their testing to proceed in advance of scientific answers as to the effects of the bomb. Physicists cast bets among themselves about whether the next bomb would ignite the atmosphere. Civilians were intentionally uninformed of their proximity to the tests, to allow governments to test the effects of radiation on humanity.

Into this scene of rising and potentially deadly conflict, Weyler introduces his Vancouverite "cast of characters," including political journalist Bob Hunter, pacifist ex-soldier Ben Metcalfe, and Quaker social activists Dorothy and Irving Stowe. This team realized that nuclear testing and the threat of nuclear warfare promised to kill our planet. They combined their strengths to develop a movement committed to gaining the general public's support for pacifism, with emphasis on ending atmospheric nuclear testing. The team shared an awareness of the power of the media, and while they understood the science-based arguments against the danger of nuclear testing, they realized that the public would be won not by numbers, but by images.

Hunter called these images "mindbombs": they were "simple images, delivered by the media, that would 'explode in people's minds' and create a new understanding of the world" (73). The team realized that whoever has the best picture wins, and set out to use this knowledge to their advantage. As ecological and disarmament goals merged, the group found their identity advocating not only peace, but an environmentally-aware peace, a *green* peace, and thus found their name.

The newly formed Greenpeace realized that protest groups had been largely ignored in the past because they weren't demanding to be seen. Greenpeace decided to sail a boat into the middle of the next scheduled nuclear explosion, a United States test scheduled to take place in October of 1971 on Amchitka Island, a "registered National Wildlife Refuge" (55). By placing themselves in the middle of the event, and ensuring that dramatic photographs and news stories were released to the media, Greenpeace guaranteed that their campaign could not be overlooked. Though this initial campaign, the sailing of the *Greenpeace I* and *II*, did not prevent the bomb from being detonated (creating "the largest human-made earth tremor in history," (131) a 7.2 magnitude earthquake), the mission was nevertheless a success. They had informed politicians and the general public of the dangers of the bomb, and had made their case for the futility of the arms race. As protests erupted around the world, atmospheric nuclear testing became an embarrassment to the United States government, and experiments soon moved underground. Other countries followed suit, after similar pressure and embarrassing attention from Greenpeace groups.

The strategy proved successful: Greenpeace had lodged itself between the aggressor and the resource they aimed to protect, and people took notice. The movement grew, and attracted new activists. With the anti-nuclear success, the group shifted its attention to environmental injustices. Biocracy, the right of each living thing to be respected, became the credo of the group, as reflected in the "Greenpeace ecology manifesto," titled the "Declaration of Interdependence" (393). Individual Greenpeace members maintain individual ecological vision, and while this varies from member to member, most seem to be deep ecologists, maintaining that the survival of each living thing is dependent on the ecosphere at large; no species, including humans, takes priority over another. Greenpeace as a whole adamantly proclaims its "fundamen-

tal values" as "peace, tolerance, bearing witness, ecology, innovative direct action, [and] non-violence" (489).

One of the new attendees at Greenpeace meetings, Dr. Peter Spock, a psychologist who had come to realize the enormous intelligence and complex brain waves of whales, advocated that their protection from whaling fleets should be the focus of the next Greenpeace campaign.

Fleets of whaling ships, including factory boats that would process the whales while still at sea, had hunted the world's whales to dangerously low levels, pushing some species to extinction. The Greenpeace team decided to emulate their successful anti-nuclear tactics, and again place themselves between the aggressor and the victim: they will pilot zodiacs between the whaling ships and the whales. This proved an enormously dangerous task, as the whaling ships were equipped with canon-fired harpoons, and the whalers were often not persuaded by the activists' presence to hold their fire. Nevertheless, the Greenpeace team time and again positioned themselves between the guns and the whales, all the while snapping pictures to send to worldwide media, communicating the gory horror of the whale hunt. As with the anti-nuclear warfare campaign, Weyler relates devastating statistics about the depletion of the whale population, simultaneously explaining the need for change and campaigning further to his readers.

Both the anti-nuclear and the anti-whaling campaigns had found success, but the split-focus had divided the group. Names, places, and projects proliferate in the latter section of the book, speaking to the new nature and diversity of Greenpeace. However, funds were limited, and members disagreed about priorities. Further dividing the group was a new interest in an anti-sealing campaign. Sealers off the coast of Newfoundland and Labrador slaughtered hundreds of thousands of white coat seal pups each season, a hunt that Greenpeace claimed was rapidly and dangerously depleting the seal numbers. Greenpeace activist Paul Watson advocated spraying the pups with a harmless green dye, which would make them worthless to the fashion industry to which their pelts are usually sold. The team set out for Newfoundland, with this intent. They were not well received by Newfoundlanders, who viewed them as outsiders, without right to decide on Newfoundlanders' means of income.

Realizing the support of Newfoundland was vital, Hunter agreed to abandon the green dye idea, in favour of direct confrontation with the sealing companies. The focus, Hunter maintained, was not the sealers themselves, but the foreign factory ships that employed the sealers for very little, and sold the seal pelts at a great profit. This focus seemed to appease the Newfoundland sealers, who guardedly welcomed the Greenpeace activists. While Weyler makes mention of the realization that this is an economic as well as an environmental problem, and briefly alludes to a campaign to replace a portion of the wages of sealers who would agree to give up their work, this vital aspect of the problem is not pursued. The anti-sealing campaign continued, but did not present an economic alternative for sealers.

The group became increasingly divided as Watson, frustrated over the slow pace of success in Newfoundland, advocated for a more aggressive approach in confronting environmental abuse. Greenpeace, however, remained staunchly committed to non-violence, and Watson left to form his own campaign, the Sea Shepherd Society. A faction of Greenpeace remained committed to the seal campaign, and there seemed now to be three separate Greenpeaces, each competing for funds, each demanding that their own campaign was most important. A suggestion arose from the group: "If we're ecologists, then let's rise above our particular issues to see the bigger pattern" (231). Despite their vision of an ecologically-just society, it became clear that, amidst all of their funding problems and internal bickering, they were not promoting balance, nor were they celebrating diversity. As their debt mounted, they gave in to pressure from Greenpeace groups that had formed worldwide to give up Vancouver control, and merge with newer collectives to become Greenpeace International. Though the Greenpeace campaign lives on, its focus is no longer Canadian, and Weyler's retelling ends here.

The continued international presence suggests that this truly is "the movement the world needs" (135). Projects continue to proliferate: as www.Greenpeace.ca clearly evidences, "the ecological crisis seems to be expanding on an exponential trajectory" (352). It will be of great benefit to those motivated to participate in today's Greenpeace campaigns to know something of the roots of the movement.

Weyler makes only brief mention of a common criticism leveled at Greenpeace; the rising feminist movement called the Greenpeace Foundation sexist, and perhaps rightfully so. Feminists accused the largely-male collective of militaristic language and macho and aggressive tactics. Hunter suggested at the time that a forceful and aggressive strategy was necessary to ensure that their environmental concerns were heard. Weyler himself doesn't take the claims to task: instead, he allows the history of the movement to speak for itself. Throughout this history, he highlights the contributions of women to the campaign, and follows the story of Susi Newborn's efforts to launch the first Greenpeace UK boat, the *Rainbow Warrior*, on a hugely successful mission. The concerns of ecofeminists, however, seem to stand, even as Hunter's motto "A flower is your brother" (150) changed to the more inclusive "A flower is your brother *and* your sister" (489). Other criticisms, such as the now common concern that the boats Greenpeace uses for its eco-interventions are themselves far from eco-friendly, remain unaddressed. But perhaps such silence is justified: Weyler doesn't set out for himself the task of justifying Green-

peace. Instead, he recounts the passions that formed the movement and kept it motivated, and the inner conflicts that forced its evolution.

The history certainly has its shortcomings. A tiresome *Lord of the Rings* analogy runs throughout the 574 pages of text, and the foreshadowing of future Greenpeace trouble is almost constant. Most distracting is Weyler's tendency to tediously set a scene, detailing the room, the lighting, and even the contents of paintings hanging on the walls. But his goal is as much to convey the emotion as the historical record of these first nine years, and the details help to transport the reader to the time and place remembered. (Weyler's elaborate scene-setting becomes slightly more understandable once we learn that he is the group photographer.)

Ultimately, Weyler's passion and enthusiasm for the ideals of the Greenpeace movement are shared with the reader in a style that is politically, scientifically and historically informed, making his book the perfect starting point for anyone who is looking for either a history of Greenpeace, or the inspiration to become politically and environmentally active. This history, I think, will make Greenpeace'rs proud, as it functions as a mindbomb: reading about Greenpeace's commitments, their successes and failures, awakens an awareness of the potentials of eco-activism within each reader. You can put the book down, but you can't stop thinking about it...

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The Last Great Sea: A Voyage Through the Human and Natural History of the North Pacific Ocean

By T. Glavin. 2000. David Suzuki Foundation and Greystone Books Douglas & McIntyre Publishing Group, Vancouver/ Toronto, Canada. 244 pages, $34.95 hardcover.

This book belongs in every conservationist's bookshelf, to say the least. As D. Suzuki describes very convincingly in the foreword, the environment of today's North Pacific is characterized by its loss of (fish) species and its wipe-out of protein assemblages. The collapse of Sockeye Salmon is only one of many sad examples, many more exist: Steller's Sea Cow, Spectacled Cormorant, Dwason's Caribou (Queen Charlotte Islands), and even plant species like Tobacco (Queen Charlotte Islands). Other species like Walruses, Sea Otters and Fur Seals barely survived until now.

The first chapter starts slow but allows a very solid overview about historical and archaeological facts. Already after Chapter 2, nobody can deny anymore the environmental disaster and mis-management of the North Pacific and coastal British Columbia. Nevertheless, the author convinces the reader that the North Pacific still is THE largest fish producer in the world. "As in aboriginal fisheries, mythology played a part in industrial fisheries management, especially the myth of a superabundant ocean and the all-powerful capability of science and technology to fix the messes made by hydroelectric dams, lousy forestry practices and overfishing". The governmentally encouraged Merganser Control and Bear Shooting Programs designed for the sake of Salmon Protection prove this citation very well. Galvin strongly eliminates all illusions on how to heal the problem of overfishing. For instance, he shows that S. Livingstone's widely followed idea of Fish Hatcheries does not produce more salmon, but instead takes away funds and harms natural salmon stocks since they simply replace the last remaining and struggling stocks with poorly adjusted new ones. Strong also are Gavin's arguments against Salmon Farming; e.g., it contributes to the closure of marine fisheries for wild salmon, and it requires 3 kg of fish to produce 1 kg of salmon.

Fisheries and the ecology of all major North Pacific fish species get well-covered in this book. Since the abundance of salmon shaped western North America, this topic receives major attention in the text. All Pacific salmon species are discussed: Chum, Sockeye, Pink, Coho, Steelhead, Masu and Amago. Of major interest is in this regard the scientific discussion around the taxonomy of salmon; e.g., Steelhead (classified until 1980s as Trout). The author brilliantly points out the implications of the religious-based and somewhat outdated taxonomical system by Carl von Linné, and how this affects the species management by national governments (provincial and federal) on an international level even (Canada vs. USA).

The backwardness and failure of fishery laws are shown by outlining that the first salmon-fishing regulations for the Fraser River was a simple word-for-word replication of fishing regulations on English Rivers. At that time, Canada's external affairs jurisdiction was still controlled by the British, which affects the Canada-U.S. salmon treaty concluded 1930s and renewed in 1985. In addition, Galvin shows that Canadian and U.S. fishery scientists significantly differed in their stock assessment results for the same species in the same waters even; consequently, so did the management and political agendas. This is the classical picture of "mixed-stock" fisheries, which also threatens small salmon runs.

The author reports the incidental death of 50 000 marine mammals and 500 000 seabirds due to driftnet fishery activities in the North Pacific; marine (plastic) pollution comes with it. Despite the well shown failure of a European and Western approach dealing with the North Pacific fisheries, domestic Japanese and Native fisheries seemed to work well and be sustainable. Galvin shows the magnitude of "pre-contact" fish-

ery for salmon by natives, which was even comparable with levels of commercial fisheries from this century. Some readers might find that the book slightly follows stereotypical views of the noble native.

A very strong point in this book is how the North Pacific and its fauna is linked with the "hinterland": Old-growth rainforest, landscape and Bald Eagles. This needs to be considered in the light that resident Killer Whales in British Columbia are among the most contaminated cetaceans of the world.

A very complete picture of the North Pacific is portrayed by fully considering the Russian influence and history. The book outlines well that Russian settlers did much better than the western type of colonization (a point that might be put in doubt for the Kodiak Islands at least). The Russian-American Company was much more relevant in the history of North Pacific settlements and explorations than the Hudson Bay Company (HBC). But nevertheless, as with the HBC, the Russian quest for the North Pacific had the same motivation: central European pelt resources were already overhunted!

Regarding the marine ecology of the North Pacific, the importance of the Aleutian low, Pacific currents, and El Niño are fully described. This ecosystem is driven by "regime changes", which calls for a dynamic management. The author outlines this very well by presenting the ground-breaking work from Russian Scientist T. Baranov, but also from Bill Ricker "Ricker curve" and others at the Pacific Biological Station, e.g., G. McFarlane and D. Beamish. A quote from the book says it all: Understanding catch statistics is like "reading a single faded and crumbling onionskin page from an early draft of Wagner's Tannhaeuser, in a dimly lit room". Another quote of the book and taken from the U.N. Code of Conduct for Responsible Fisheries states, in part, that "the absence of adequate scientific information should not be used as a reason for postponing or failing to take conservation and management measures". Well said.

Galvin makes a strong case that ethnocentric approaches for understanding and managing the North Pacific have failed, e.g. the Chinese might have been in North America much earlier than the Europeans. The book elaborates on the major question "who came first" since it had such a major economical and political implication for European powers. A major conclusion from this book is that there never was such a thing like an Old World (Eurasian) and New World (Americas).

The chapters on anthropology and human history of the North Pacific and how the Russians, Asians and Natives settled and explored the North Pacific are on the same level than high-caliber books as *Guns, Germs and Steel* by J. Diamond. Just to name some highlights, Glavin mentions how natives grew Arrowhead and potatoes, he cites the work of the Russian Anthropologist S. Fedorova, and he documents that Hawaiians, Japanese, Chinese and Russians presented a major group of settlers. In addition, the book reports a lot of British Columbian and Vancouver history and puts Canada in the context of the overall Pacific.

Despite the fact that whaling, sealing and eating dolphins is as old as the human history of the North Pacific, whale watching (starting as early as 1907) has already produced more profit than commercial whaling ever did for western North America. Greenpeace started in Vancouver, it "was born in the blood of whales". Nevertheless, the author shows that already in the 19th century the pelagic seal hunt provoked the first great international controversy about the overharvesting of the world's marine mammals. It resulted in the international milestone contract ("fur seal treaty") of 1911 between Russia, Japan, Canada and USA.

Topics mentioned in the seven chapters of this book are so manifold and detailed that only some can be mentioned in this review: Bute Wax, Russian scientist K. V. Belkemishev, occurrence of pilchards in British Columbia, oolichan grease, geoduck, Pollock fisheries, Korean squid fisheries, canneries, Earth Rotational Velocity Index, J. Cook, G. Vancouver, V. Bering and J. J. Walbaum. Although the author emphasizes the problems with old-fashioned type of science for the North Pacific, the book is actually based on scientific publications. The index and the annotated scientific references will be highly appreciated by the scholar. This text book (no pictures but five maps) has no shortcomings.

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Quantitative Conservation Biology: Theory and Practice of Population Viability Analysis

Morris, W. F., and D. F. Doak. 2002. Sinauer Associates Inc., Sunderland Massachusetts USA. ISBN 0-87893-546-0 paperback (41.95 US$)

This is a great book, which should affect how we research and manage wildlife and its controlling factors. The topic of a Population Viability Analysis (PVA) is not really new, but there are only few books that describe the topic well for the general public and managers. "PVA is the use of quantitative methods to predict the likely future status of a population or collection of populations of conservation concern".

"The promise that PVA holds as a tool for guiding conservation decision-making has been recognized by governmental science advisory boards, by professional organizations such as the Ecological Society of America and by nongovernmental conservation organizations such as The Nature Conservancy." This statement also holds for the Habitat Conservation Plans and for the Recovery Plans of the U.S. Endangered Species Act. However, "Instead of seeing PVA as a valuable tool to aid their decision making, most field-oriented conservation biologists retain the misinterpretation

that PVA models can only be constructed and understood by an elite priesthood of mathematical population ecologists".

Fortunately, this book is supposed to make PVAs easier to understand. It is based on the advanced matrix-based population modeling concept and uses count-based and demographic PVAs. The authors present actually a very good introduction to demographical population studies and even to the relatively new AIC concept. It explains its concepts with examples from a great variety of different animal and plant populations world-wide. The authors do a great effort to explain important concepts such as Vital Rates, Lambda, Bonanzas and Catastrophes, Density Dependence, Ricker Curve, Beverton-Holt Model, Log-Population Growth Rate, Accounting for Errors, Environmental Stochasticity, Sensitivity Analysis and many others. As a key take-home message from this book I see the authors' focus on confidence intervals, rather than the pure population means. Such an approach embraces the uncertainty among population estimates in a much more transparent fashion than usually done. Many conservationists world-wide have encountered the sad but so often true statement made by the authors: "While data uncertainties are frequently used as a reason to rely solely on expert opinion – or on simple political expediency – when deciding difficult issues, we believe that use of more formal analyses can frequently benefit conservation practice. In the absence of such scientific analysis of conservation situations, personalities, politics, and dollars will drive what actions are and are not taken, often with little or no regard to their real conservation value".

The reader will also learn in this excellent PVA-book about the great importance of the extinction-time cumulative distribution function, plotted against years into the future. As the authors show, there are five measures to express extinction risk: the probability of extinction by a given time, the probability of extinction ever occurring, and the mean, median and model times to extinction. Of these, only the first three are the most useful, but the last two are still the ones most often used.

This book has contributing software in MATLAB and SAS code (also available on the website www.sinauer.com/PVA/), which the practitioner will benefit from. Fourteen pages of literature references and a well-organized index will be very helpful to the reader as well.

Despite the "how to" focus of the book, I find the text is not that easy to understand, and it refers the reader too often all over the book. So from my experience, I suspect that most managers will not really read it, nor fully understand all relevant (statistical) details; the mathematical codes alone take up an Appendix. The book on how to link PVAs with Geographic Information Systems (GIS) still awaits to be written.

In either case, I admire in this book that is promotes an overall quantitative approach to wildlife conservation, and specifically I love the last chapters; e.g., Management with Uncertainity, Multiple Site PVAs, Viability-Analysis for Spatially Structured Populations and When and When Not to Perform a PVA (a great argumentation help when doing PVAs). There just is no escape from numbers and reliability in this important conservation field.

This important book makes it clear that well-designed demographical studies and PVAs are nowadays among the basics for any wildlife population to be studied and managed. It provides crucial tools for a quantitative wildlife monitoring and conservation in the new millienium. Now it's once more up to the managers to read, to understand, and fully implement all relevant lessons learnt from this baseline publication.

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Their Fathers' Work: Casting Nets with the World's Fishermen

By W. McCloskey. 2000. International Marine/McGraw-Hill, P.O. Box 182604, Columbus, Ohio 43272 USA. 370 pages, $20.95 Paper.

This book provides the reader with a superb and highly praised overview of global fisheries, focusing on Alaskan waters. In addition, it also covers first-hand experiences for offshore and coastal fisheries with vessels from Japan, Chile, Indonesia, Newfoundland (Grand Banks), Maine (Georges Bank), Iceland and Norway. The book is very pleasant to read since it combines fiction with facts. It is a heroic and romantic description of a likely soon-to-be-gone life of hard work. Nevertheless, reading how other people work very hard and under life-threatening conditions might present some sort of decadence; but so be it.

In case the reader would not be familiar with how to cheat in the business of international fisheries and quotas (led by Spain, Taiwan, Japan and many East European nations) this book will definitely help. It outlines in detail how fishing quotas are easily doubled, if not ignored by many vessel captains and fishermen worldwide. The explicit use of Dynamite Fishing, Liner Nets (an additional net with an illegally smaller meshsize put inside the regular net), the "Pareja" Method (one huge net pulled by two boats) and many other tricks are shown and suggested; e.g., the same vessel being registered with two different names (thus, multiplying the quota by two), stowing an additional catch somewhere under deck, trading the catch offshore (therefore enabled to start again with a "new" quota),

and mis-reporting catches. When fisheries officers appear for control and gear inspection, nets simply get cut off (which makes it even worse for fish, seabirds and sea mammals that drown in the "ghost nets" later). Overall, I find that the author, an American, might have a tendency to blame the Spaniards and Russians too much here. Instead, a mention and description of the role that the Vladivostok-based Russian fisheries plays, acting worldwide, could have made the book even better.

The thorough understatement of environmental damage done by coastal and offshore fishery must be of concern to any informed naturalist. The author neglects to address the destructive fishery method from draggers ("seafloor dredging"), which is, for instance, estimated to damage an area larger than that lost through deforestation in the tropics. There is no mentioning of fisheries gear polluting beaches worldwide, or "ghost nets" which float around in the world's oceans for years (eventually, they will sink, but only the fish know whether they will ever rot). Sensitive by-catch topics such as the endangered Short-tailed Albatross (*Phoebastria albatrus*) caught by freezer-longliners fishing off Alaska are not mentioned, and certainly there is no reporting of the numerous sea turtles, sharks, dolphins, porpoises, seabirds, moon fishes and many other species suffering and dying for the sake of high quality fish. In times of environmentalism, that might be seen as a short coming of this book. Although the occurrence of a "black catch" is somewhat mentioned, one has to read that shrimp fisheries has apparently almost no by-catch. The reader has to keep his/her breath when McCloskey mentions "overpopulations" of Sockeye and seals; 50 000 seals are described as an "overpopulation" rather than victims in a potential by-catch problem. No wonder, the author identifies clearly from the "fishermen's side", blames Greenpeace, and does not place fisheries in the overall context of the environment; instead, he mostly focuses on economical and descriptive aspects of fisheries. In this regard, the author's presentation of Chile's fishery development lacks sensitivity to the well-proven and negative effects of over-commercialization. On the other side, his wonderful and detailed presentation of the effects from the Exxon Valdez Oilspill for Alaska and its island communities compensate for the previous short-comings. A remarkable link is shown why the prizes of the Japanese Salmon market are driven by cycles of the Japanese Salmon runs, and thus dictate the Alaskan Salmon fisheries. McCloskey gets closer to the heart of the fisheries problem when outlining that improved efficiency and introduction of very light, and therefore allowing for longer, plastic nets has contributed to the current overfishing crisis.

In the numerous and fascinating book chapters the author also emphazises and describes that there exists such a thing as severe overfishing: Snow Crab in Alaska; Cod , Flounder and Squid in Newfoundland; and Halibut off West America. He blames governmental mismanagement and elaborates nicely throughout the text that there is also conflict of interest among fishermen on these topics; e.g., unions, and small scale fisheries vs. industrialized trawlers. In the context of governmental mismanagement, New Zealand's Orange Roughy, a prime example of overfishing and disastrous fisheries management, could have been mentioned, too. The book would have gotten even better when topics such a Native Fishery Rights, North Sea Fisheries and Krill Fisheries in the Antarctic would have been included. The map of the Grand Banks lacks the French Fisheries zone around St. Pierre and Miquelon; but the reader will appreciate that this book has a very detailed index, which allows that it can serve as a valid source of references, too.

The book ends with a well-written and conclusive section on global fisheries and policy. The author quotes from one of his many interviews with experts: "Gathering fishery statistics is an art in probability". That statement makes it clear that, currently, there can be no sustainable world fisheries. Due to the many topics covered, I thoroughly enjoyed reading this book and got literally "hooked".

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MISCELLANEOUS

How the Earthquake Bird Got its Name and Other Tails of an Unbalanced Nature

H. H. Shugart. 2004. Yale University Press, New Haven, USA. 227 pages.

What do the following five birds, four mammals and one marsupial have in common: Ivory-billed Woodpeckers, penguins, packrats, Bachman's Warblers, Leadbeater's Possums, Red-billed Queleas, Beavers, Giant Moas, Gray Wolves, and European Rabbits? Several are extinct, a few are very numerous, some are common, and others are rare. They all have been chosen by Shugart who, with charm and panache, introduces the reader to a wide range of ecological concepts under the rubric of animal parables.

Shugart, the W. W. Corcoran Professor and Director, Global Environmental Change Program at the University of Virginia, presents nine ecological concepts: forest gap dynamics, niche theory, paleoecology, ecological disturbance, migration, keystone species, island biogeography, domestication, and invasive species. These ecological principles are not presented in a "pristine" form, but are embedded within the context of human transformation of the earth's landscapes and

how these transformations relate to animal extinctions and explosions.

Shugart introduces each concept with an animal story that sets the stage for an intelligent and entertaining journey through a mélange of natural and human history. Did you know that the word "penguin" comes from two Welsh words? *Pen* is the Welsh word for head and *gwyn* is Welsh for white. Penguins do not have white heads, but were actually named for the great, guano-whitened headlands on an island near Newfoundland (Funk Island). The birds of interest, however, were not penguins as we know them from the Antarctic region, but actually auks, of which the now extinct Great Auk was the one most familiar to the sailors of the day. The Great Auks were named penguins long before European mariners misnamed the similar looking but unrelated penguins of the southern and Antarctic waters. Being from Newfoundland, I found this little tidbit delightful. This is typical of the manner in which Shugart expertly weaves natural and human history into an attractive and colourful mosaic.

The packrat and its middens introduce the reader to the world of paleoecology, of the archival nature of tree rings, ice cores, and pollen deposits that reveals a dynamic and ever-changing earth. The African grassland Red-billed Quelqua, apparently the most common bird on earth, initiates the reader to a marvelous treatment of bird migration that is sobered by an account of the extinction of the once numerous Passenger Pigeon. Shugart's account of the Wolf (*Canus lupus*) introduces us to the domesticated wolf or dog (*Canus domesticus*) and the history of animal domestication by our ancestors. To see how humans have radically altered natural landscapes without metal or modern devices, one has only to turn to the domesticated grazers.

If you are looking for support of notions such as "the balance of nature" or "unspoiled, pristine wilderness" you will be disappointed. Shugart explicitly eschews such notions. His objective is to "provide an alternative view, to give insights into the dynamically changing nature of ecosystems and the implications of this dynamism for our stewardship of the planet" (page 2). According to Shugart, the only constant in nature is change. For him, planetary management or stewardship is the human vocation; a vocation that is defined, not by hubris, but rather by an acknowledgement of the long and continuing history of human alteration of planetary ecosystems, and the need for intentional and responsible human action. It is within this paradigm that we must understand the myriad of conservation and ethical challenges that face us.

This work will pique the interest of all naturalists. Shugart's writing is far from being pedantic or stogy. He writes with passion, charm and clarity about a subject that has no doubt become a vocation. A wealth of original ecological research is synthesized in a delightfully accessible manner that relates to our proverbial interest in the wax and wane of animal species. Why are some species abundant and others rare? Why does one species response positively to human influence, while other species meet extirpation or extinction? The detailed and helpful notes serve well the interested reader who wishes to pursue further research.

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NEW TITLES †Available * Assigned

Zoology

Amphibians and Reptiles of the Bay Islands, and Cayos Cochinos, Honduras. By J. McCranie, L. Wilson and G. Köhler. 2005 Bibliomania! P.O. Box 58355, Salt Lake City, Utah 84158. 224 pages. U.S. $29.95 Cloth.

Amphibians and Reptiles: Status and Conservation in Florida. 2005. By W. Menshaka and K. Babbitt. P.O. Box 9542, Melbourne, Florida USA. 32902-9542. 334 pages. U.S. $66.50.

Bird Coloration – Volume 1. By G. Hill and McGraw. 2005. Harvard University Press, 100 Maple Ridge Drive, Cumberland Rhode Island 02864-1769. 544 pages. U.S. $95.

*** Birds of New Brunswick: An Annotated list. (Oiseaux du Nouveau-Brunswick: une liste commenteé.)** By David Christie et al. 2005. New Brunswick Museum, Monograph No. 10, 277 Douglas Avenue, Saint John, New Brunswick E2K 1E5. 84 pages. not illustrated, no price available.

Birds of Ontario: Habitat Requirements, Limiting Factors and Status (Nonpasserines, Waterfowl through Cranes). By. A. Sandilands. 2005. UBC Press, 2029 West Mall, Vancouver, British Columbia VST 1Z2. 366 pages. $95.

Birds of Two Worlds – The Ecology and Evolution of Migration. Edited by Russell Greenberg and Peter P. Marra. The Johns Hopkins University Press, 2715 North Charles Street, Baltimore, Maryland 21218-4363. £15.50 Cloth.

*** Blue Grouse – their Biology and Natural History.** By F. Zwickei and J. Bendall. 2005. NRC Research Press, M-55, National Research Council, Ottawa, Ontario K1A 0R6. 284 pages. $69.95 Paper.

Crows. By Candace Savage. 2005. Greystone Books, Suite 500, 720 Bathurst Street, Toronto Ontario M5S 2R4. 120 pages. $27 Cloth.

Dragonflies of Sussex. By T. A. Belden et al. 2004. NHBS Ltd., 2-3 Wills Road, Totnes, Devon, Great Britain TQ9 5XN. £7.95 Paper.

Duikers of Africa: Masters of the African Forest Floor – A Study of Duikers – People – Hunting and Bushmeat. By Vivian J Wilson. 2005. NHBS Ltd., 2-3 Wills Road, Totnes, Devon, Great Britain TQ9 5XN £125 Cloth.

Florida Butterfly Caterpillars and Their Host Plants. By M. Minno, J. Butler and D. Hall. 2005. University Press of Florida, 15 NW 15th Street, Gainesville, Florida 32611. 352 pages. US$34.95.

*** The Natural History of Bermuda.** By M. Thomas. 2005 The Bermuda Zoological Society P.O. Box FL 145 Flatts, Florida BX Bermuda. NPA.

Biology of Gila Monsters and Beaded Lizards. By Daniel D. Beck. 2005. NHBS Ltd., 2-3 Wills Road, Totnes, Devon, Great Britain TQ9 5XN. £26.50 Cloth.

Parenting for Primates. By H. Smith. 2005. Harvard University Press, 100 Maple Ridge Drive, Cumberland, Rhode Island 02864-1769. 394 pages. US$29.95.

Secret Weapons – Defenses of Insects, Spiders, Scorpions and Other Many-legged Creatures. By T. Eisner, M. Eisner and M. Singer. 2005. Harvard University Press, 100 Maple Ridge Drive, Cumberland, Rhode Island 02864-1769. 365 pages. U.S.$29.95.

The Smaller Majority (Frogs, insects and others). By P. Naskreki. 2005. Harvard University Press, 100 Maple Ridge Drive, Cumberland, Rhode Island 02864-1769. 364 pages. U.S.$35.

† Wheatears of the Palearctic – Ecology, Behaviour and Evolution of the Genus *Oenanthe*. By E. Panov. 2005. Pensoft Publishers, Geo Milev Street 13a, 1111 Sofia, Bulgaria. In English, pages. U.S.$58.80. Cloth.

† Land Snails of British Columbia. By R. Forsythe. 2005. Royal BC Museum, 675 Belleville Street, Victoria, British Columbia V8W 9W2. 192 pages. $25.95.

*** Monitoring Bird Populations Using Mist Nets.** By C. Ralph and E. Dunn (eds). 2005. Cooper Ornithological Society. 211 pages. U.S.$23 Paper

Nests, Eggs, and Nestlings of North American Birds (Second Edition). By P. Baicich and C. Harrison. 2005. Princeton University Press, 41 William Street, Princeton, New Jersey, 08540-5237 USA. 416 pages. U.S.$29.95

Out of the Blue – a Journey through the World's Oceans. By P. Horsman. 2005. The MIT Press, Five Cambridge Center, 4th Floor, Cambridge, Massachusetts 02142-1493 USA. 160 pages. U.S.$22.95 Cloth.

Walker's Carnivores of the World. By Ronald M. Nowak. 2005. The Johns Hopkins University Press, 2715 North Charles Street, Baltimore, Maryland 21218-4363. £15.50 Paper.

Botany

Forests in Landscapes – Ecosystem Approaches to Sustainability. Edited by Jeffrey A. Sayer and Stewart Maginnis. 2005. NHBS Ltd., 2-3 Wills Road, Totnes, Devon, Great Britain TQ9 5XN £29.95 Cloth.

Forest Pathology: From Genes to Landscapes. Edited by J. E. Lundquist and R. C. Hamelin. 2005. The American Phytopathological Society/APS Press, 3340 Pilot Knob Road, Saint Paul, MN 55121. 175 pages. U.S.$69. Paper.

Primates of Colombia. By R. T. Defler. 2005. Conservation International – Tropical Field Guide Series. NHBS Ltd., 2-3 Wills Road, Totnes, Devon, Great Britain TQ9 5XN. 550 pages. US$40.00. Paper.

Trees – National Champions. By R. Conover. 2005. The MIT Press, Five Cambridge Center, 4th Floor, Cambridge, Massachusetts 02142-1493, USA. 144 pages. US$39.95.

The Vascular Plant Red Data List for Great Britain – Species Status 7. Edited by C. M. Cheffings and L. Farrell softcover. 2005. NHBS Ltd., 2-3 Wills Road, Totnes, Devon, Great Britain TQ9 5XN. £15Paper or as a download see – http://www.jncc.gov.uk/page-3354.

Environment

† Survival by Hunting – Prehistoric Human Predations and Animal Prey. By G. Frison . 2005 University of California Press, 2120 Berkeley Way, Berkeley, California 94704-1012.

Wild Prairie. By J. Page. 2005. Greystone Books, Suite 500, 720 Bathurst Street, Toronto Ontario M5S 2R4. 144 pages. $45. Cloth.

Aquatic Food Webs – An Ecosystem Approach. Edited by A. Belgrano, U. Scharler, J. Dunne and B. Ulanowicz. 2005. NHBS Ltd., 2-3 Wills Road, Totnes, Devon, Great Britain TQ9 5XN. £39.95 Paper.

Beyond Conservation – A Wildland Strategy. By Peter Taylor. 2005. Earthscan / James & James, 8-12 Camden High Street, London NW1 0JH, UK. £59.99 Cloth.

*** Manly Hardy (1832-1910): The Life and Writing of a Maine Fur-Buyer, Hunter, and Naturalist.** By William B. Krohn. 2005. Maine Folklife Center, 5773 So. Stevens Hall, University of Maine, Orono, Maine 04469. 343 pages. US $24.95. Hardcover. US$19.95. Paper.

Marine Conservation Biology – The Science of Maintaining the Sea's Biodiversity. By Elliot A. Nourse and Larry B. Crowder. 2005. Island Press, 1718 Connecticut Ave, NW, Suite 300, Washington DC, 20009. £33.50 Cloth.

Ocean and Coastal Conservation Guide 2005-2006 – The Blue Movement Directory. By David Helvarg. 2005. Island Press, 1718 Connecticut Ave, NW, Suite 300, Washington DC, 20009. £18.50 Paper.

Out of Gas – The End of the Age of Oil. By David Goodstein. 2005. NHBS Ltd., 2-3 Wills Road, Totnes, Devon, Great Britain TQ9 5XN. £8.99 Paper.

Secret Nature of Devon. By Andrew Cooper. 2005. NHBS Ltd., 2-3 Wills Road, Totnes, Devon, Great Britain TQ9 5XN. £12.95 Paper.

Spatial Analysis – A Guide for Ecologists. By Marie-Josee Fortin and Mark Dale. 2005. NHBS Ltd., 2-3 Wills Road, Totnes, Devon, Great Britain TQ9 5XN. 365 pages. £53.99 Cloth, £26.99 Paper.

News and Comment

Marine Turtle Newsletter (108)

April 2005. 36 pages: ARTICLES: Record 42 Kemp's Ridley nests found in Texas in 2004 — Sea turtle strandings and mortality in Ecuador 1994-1999 — Observations of marine turtles during seismic surveys off Bahia, northwestern Brazil — Zakynthos sea turtle odyssey — A political ball game — NOTES: Hurricane effects on nesting *Caretta caretta* — Loggerhead Turtles in the Dalyan River, Mullga Province, Turkey, 2004 — IUCNMTSG UPDATE — MEETING REPORTS — BOOK REVIEWS — ANNOUNCEMENTS — NEWS & LEGAL BRIEFS — RECENT PUBLICATIONS.

The Marine Turtle Newsletter is edited by Brendan J. Godley and Annette C. Broderick, Marine Turtle Research Group, Centre for Ecology and Conservation, University of Exeter in Cornwall, Tremough Campus, Penryn TR10 9EZ United Kingdom; e-mail MTN@seaturtle.org; Fax +44 1392 263700. Subscriptions and donations towards the production of the MTN can be made online at <http://www.seaturtle.org/mtn/> or postal mail to Michael Coyne (online Editor) Marine Turtle Newsletter, 1 Southampton Place, Durham, North Carolina 27705 USA (e-mail: mcoyne@seaturtle.org).

The Boreal Dip Net/L'Epuisette Boreale: Newsletter of the Canadian Amphibian and Reptile Conservation Network/ Reseau Canadien de Conservation des Amphibiens et des Reptiles 9(1) April 2005

Editor's Note (Kerrie Serben) — Snakes on tour — CARCNET and *Sciensational Ssnakes!!* Team up to provide public education (Jeff Hathaway) — South Okanagan spotlight on species: Tiger Salamander (Susan L. Ashpole and Peter Ord) — Evaluation of the Eastern Massasauga Rattlesnake public education and outreach program in the Bruce Peninsula and eastern Georgian Bay region (Sean Liipere) — Notes from the field (Larry Halverson) — Herping in Costa Rica (Jonathan Choquette) — Advances in anuran apprehension, a technical note (Frederick W. Schueler) — CARCNET increases membership fees to $29 per year (David A. Galbraith) — 9th Annual Living Lakes Conference (Larry Halverson) — Upcoming Meetings of interest — Recent articles of interest.

Membership in CARCNET/RECCAR (contact Bruce Pauli, Canadian Wildlife Service, National Wildlife Research Centre, Carleton University, Raven Road, Ottawa, Ontario K1A 0H3. Web site: http://www.carcnet.ca/).

Ontario Natural Heritage Information Centre Science and Information Newsletter 10(1) Winter 2005

Contents of this 20 page issue: NHIC adopts BIOTICS software — Protecting Ontario's biota: Your species field notes — Shadowdragons in the dark: Another new dragonfly for Ontario — NHIC staff coordinate atlassing trip to the Pen Islands — Riverine alvars and prairies in southern Ontario — NHIC produces data summaries on Niagara escarpment — NHIC explores electronic handheld technology — General status of wild species update — Species at risk element occurrence records added — NHIC's involvement in the Canada-Ontario agreement respecting the Great Lakes Basin — Project to update species at risk data for National Parks — Species at risk Spotted Turtles in Muskoka and Parry Sound districts — Species at risk EO data polygon delineation project — Great Lakes conservation blueprint for biodiversity nears completion — The new species at risk (SARO) list — Two invasive aquatic plants: Fanwort and European Frog-bit — NatureServe develops invasive species assessment protocol — NHIC participates in Canadian river heritage conference — Trent University internships in conservation biology — Prince Edward County herp data files archived in NHIC — NHIC a partner in northern Ontario plant database project — NHIC adopts NatureServe's benchmark data content standards — NatureServe Canada and Canadian Wildlife Service join forces — sharing agreement with NatureServe and NatureServe Canada — Rook Reviews — NHIC staff information.

Mailing address for Natural Heritage Information Centre, Ontario Ministry of Natural Resources, 300 Water Street, 2nd Floor, North Tower, P.O. Box 7000, Peterborough, Ontario K9J 8M5, Canada; www.mnr.gov.on.ca/MNR/nhic.cfm.

CITES Control List 2005

Available on the CITES-CANADA web site www.cites.ec. gc.ca

42nd North American Moose Conference, 12–16, 2006 Baddeck, Nova Scotia, Canada

Nova Scotia Department of Natural Resources is hosting the North American Moose Conference and Workshop held at the Inverary Resort in the scenic community of Baddeck, Nova Scotia. The conference aim is to facilitate the exchange of scientific and experimental knowledge among Moose biologists throughout North America and beyond.

Conference theme:

"Management Challenges of Extremes in Population Density"

Details at: http://gov.ns.ca/natr/mooseconference.

Anthony (Tony) L. Nette, Chair, 2005 North American Moose Conference & Workshop, Manager, Wildlife Resources, Wildlife Division, 136 Exhibition Street, Kentville, Nova Scotia B4N 4E5 or call (902) 679-6140; Fax (902) 679-6176, or e-mail netteal@gov.ns.ca.

Erratum: *The Canadian Field-Naturalist* 119(1)

Seasonal diets of Newfoundland Martin, *Martes americana attrata* JOHN W. GOSSE AND BRIAN J. HEARN

Page 46: Addition to Literature Cited:

Gosse, J., J. W. Cox, and S.W. Avery. 2005. Home-range characteristics and habitat use by American martins in eastern Newfoundland. Journal of Mammalogy 86: 1156-163.

Editor's Report for Volume 118 (2004)

Mailing dates for issues in volume 118 were: (1) 15 December 2004, (2) 10 May 2005, (3), 21 August 2005, (4) 3 March 2006. A summary of membership and subscriber totals 2004 is given in Table 1. The number of articles and notes in volume 118 is summarized in Table 2 by topic; totals for Book Reviews and New Titles are given in Table 3, and the distribution of content by page totals per issue in Table 4. 118(1) featured a lead article on the History of The Ottawa Field-Naturalist's Club 1879-2005 prepared by Daniel F. Brunton at the request of council as part the recognition of 125 years of the Club's existence. I am particular indebted to Frank Pope and the Publication Committee: Ron Bedford, Bill Cody, Fenja Brodo, Karen Hamilton, Elizabeth Morton, and Joyce Reddoch; for advice, assistance in choice of illustrations, and review of this paper. Joyce Reddoch (*Trail & Landscape* files) and Robert Lee (Macoun Field Club archives) made particularly major contributions to the photo selections. Tributes in volume 118 were to Loris Shano Russell (1904-1998), Thomas Henry Manning (1911-1998) and Victor Kent Prest (1913-2003).

Council continued to contribute 40% of membership dues for publication. All of subscriptions (both individual and institutional) also go toward publication. Council also has allocated 80% of the annual interest from the Manning Fund and other capital funds to *The Canadian Field-Naturalist*. Manning fund portion is specifically to offset the publication cost of northern papers where author and institutional contributions were insufficient to cover page charges.

The journal was printed at Gilmore Printers, Ottawa, and thanks are due business representatives Emil Holst for 118(1) and initiating 118(2), and to Tom Smith for the remaining issues; to customer representatives Ally Reckzin and Chuck Graham for overseeing production and to Wendy Cotie for type inputting, formatting, and corrections for all issues. Particular tribute is due Emil Holst who was guardian and guide for Bill and I, and for my predecessor, Loraine Smith (CFN Editor 1972-1981) since the mid-1970s starting with volume 90 through associations with MOM (formally Mail-O-Matic), St. Joseph, and Gilmore printers.

Leslie Cody prepared the Index for volume 118; Elizabeth Morton proofed the galleys. Business Manager Bill Cody handled all liason with the printer and all journal business, including reprint requests and billing and oversaw and proofed the compilation of the Index. Roy John arranged for book reviews, edited them, and prepared the New Titles listing.

Manuscripts (excluding book reviews, notices, and reports) submitted to *The Canadian Field-Naturalist* totalled 75 in 2004, down 9 from 84 in 2003. The following reviewed for papers submitted in 2004 (with number of manuscripts reviewed in parentheses if more than one): **Associate Editors**: R. Anderson, Canadian Museum of Nature, Ottawa, Ontario (3); C. D. Bird, Erskine, Alberta (11); R. R. Campbell, St. Albert, Ontario; P. M. Catling, Agriculture and Agri-food Canada,

TABLE 2. Number of articles and notes published in *The Canadian Field-Naturalist* Volume 118 (2004) by major field of study.

Subject	Articles	Notes	Total
125 Aniversary	1	0	1
Mammals	21	12	33
Birds	9	9	18
Amphibians + reptiles	2	3	5
Fish	3	0	3
Invertebrates	5	2	7
Plants**	12	3	15
Multigroups	2*	0	2
Tributes	3	0	3
Totals	58	29	87

* includes articles on evironmental change in Nova Scotia and introduced marine species in Haida Gwaii region in 118(1).

TABLE 1. The 2004 circulation of The Canadian Field-Naturalist (2003 in parenthesis). Membership totals from Annual Report of the Ottawa Field-Naturalists' Club, January 2005; subscription totals compiled by W. J. Cody. Forty percent of membership dues and 100% of subscriptions go to publication of *The Canadian Field-Naturalist*. Members vote on Club affairs, subscribers and institutions do not.

	Canada		USA		Other		Totals	
Memberships								
Family & individual	717	(795)	26	(36)	6	(7)	749	(838)
Subscriptions								
Individuals	165	(163)	63	(60)	5	(6)	233	(229)
Institutions	164	(157)	246	(241)	30	(30)	440	(428)
Totals	1046	(1115)	335	(337)	41	(43)	1422	(1495)

Note: 18 countries are included under "Other" (outside Canada and United States): Australia, Belgium, Denmark, Finland, France (3: including 1 to St. Pierre & Miquelon), Germany (3), Iceland, Ireland, Japan (2), Netherlands (2), New Zealand (2), Norway (6), Poland, Russia, Spain (2), Sweden (2), Switzerland, and United Kingdom (10: including Scotland and Northern Ireland).

TABLE 3. Number of reviews and new titles published in Book Review section of *The Canadian Field-Naturalist* Volume 118 by topic.

	Reviews	New Titles
Zoology	48	69
Botany	17	16
Environment	12	35
Miscellaneous	6	2
Young Naturalists	0	4
Totals	83	126

TABLE 4. Number of pages per section published in *The Canadian Field-Naturalist* Volume 118 (2004) by issue.

	(1)	(2)	(3)	(4)	Total
Articles	118	105	135	107	465
Notes	19	17	17	16	69
Tributes	0	0	14	12	26
Book Reviews*	17	13	19	14	63
CFN/OFNC Reports **	0	2	8	3	13
News and Comment	3	2	2	3	10
Index	0	0	0	28	28
Advice to Contributors	1	1	1	1	4
Totals	158	140	196	184	678

*Total pages for book review section include both reviews and new titles listings.

**Includes CFN Editors' report in 118(2), OFNC Annual Business Meeting 118(3) and OFNC Awards 118(4).

Ottawa, Ontario (7); B. W. Coad, The Canadian Museum of Nature, Ottawa, Ontario (5); A. J. Erskine, Sackville, New Brunswick (21); D. F. McAlpine, New Brunswick Museum, Saint John, New Brunswick (7); D. W. Nagorsen, Mammalia Biological Consulting, Victoria, British Columbia (13); W. O. Pruitt, Jr., University of Manitoba, Winnipeg, Manitoba (18); **Others:** W. B. Ballard, Texas Tech University, Lubbock, Texas; J. Bart, United States Geological Survey, Boise, Idaho; R. Bedford, Ottawa, Ontario; D. R. Bennett, British Columbia Ministry of Forests, Saanichton; J. R. Bider, Ecomuseum, Ste-Anne-de-Bellevue, Quebec (2); S. Boudrup-Nielsen, Acadia University, Wolfville, Nova Scotia; J. Bowman, Ontario Ministry of Natural Resources, Peterbrough, Ontario; E. L. Bousfield, Ottawa, Ontario; J. D. Brawn, University of Illinois, Champaignn, Illinois; I. Brodo, Canadian Museum of Nature, Ottawa, Ontario; M. Burt, University of New Brunswick, Fredericton; D. J. Buckle, Saskatoon, Saskatchewan; C. M. Buddle, McGill University, Macdonald Campus, Ste. Anne-de-bellevue, Quebec; L. Carbyn, Canadian Wildlife Service, Edmonton, Alberta; W. J. Cody, Canada Agriculture and Agri-food, Ottawa; D. Cone, St. Mary's University, Halifax, Nova Scotia; M. Crête, Québec Société de la faune et des parcs, Québec; K. DeSmet, Manitoba Conservation. Winnipeg; A. W, Diamond, University of New Brunswick; L. Foote, University of Alberta, Edmonton; G. Forbes. University of New Brunswick, Fredericton; C. M. Francis, Canadian Wildlife Service, Ottawa, Ontario; J. Gilhen, Nova Scotia Museum of Natural History, Halifax, Nova Scotia (2); P. Goossen, Canadian Wildlife Service, Edmonton, Alberta; P. T. Gregory, University of Victoria, British Columbia; E. Haber, National Botanical Services, Ottawa, Ontario; P. Hamilton, Canadian Museum of Nature, Ottawa, Ontario; M. B. Hickey, St. Lawrence River Institute of Environmental Studies, Cornwall, Ontario; C. S. Houston, Saskatoon, Saskatchewan; R. James, Sutherland, Ontario (2); J. Kamler, Polish Academy of Sciences, Mammal Research Institute, Bialowieza; R. W. Knapton, Edmonton, Alberta; J. M. Knetter, University of Wisconsin-Madison; D. Langor, Edmonton, Alberta; P. F. Larsen, Bigelow Laboratory for Ocean, West Boothbay Harbor, Maine; S. Larivière, Portage La Prairie, Maanitoba; J. Leafloor, Canadian Wildlife Service, Winnipeg, Manitoba; L. E. Licht, York University, North York, Ontario; R. MacCulloch, Royal Ontario Museum, Toronto, Ontario; G. L. Mackie, University of Guelph, Ontario; C. Machtans, Canadian Wildlife Service, Yellowknife, Northwest Territories; A. Martel, Canadian Museum of Nature, Ottawa, Ontario; D. Mazerolle, University of Saskatchewan, Saskatoon; L. D. Mech, U.S. Geological Survey, The Raptor Center, University of Minnesota, St. Paul (4); J. Metcalfe-Smith, National Water Research Institute. Burlington, Ontario; E. Morton, Masham, Quebec; J. S. Nelson, University of Alberta, Edmonton, Alberta; J.-P. Ouellet, Universite du Quebec a Rimouski, Quebec; G. Parker, Canadian Wildlife Service, Sackville, New Brunswick; K. Poole, Aurora Wildlife Research, Nelson, British Columbia; E. F. Pope, Ottawa; R. Poulin, University of Alberta, Edmonton, Alberta; M. Raine, Calgary, Alberta; R. Reeves, Okapi Wildlife Associates, Hudson, Quebec (2); J. Reddoch, Ottawa, Ontario; T. E. Reimchen, University of British Columbia, Victoria: J.-F. Robitaille, Laurentian University, Sudbury, Ontario; F. W. Schueler, Oxford Station, Ontario; S. G. Sealy, University of Manitoba, Winnipeg, Manitoba; N. Simon, Newfoundland and Labrador Natural Resources, Goose Bay; B. Slough, Whitehorse Yukon Territory; S. Smith, Univerisity of Toronto, Ontario; K. W. Stewart, Winnipeg, Manitoba; J. Theberge, Oliver, British Columbia; I. Thompson, Canadian Forest Service, Sault Ste. Marie, Ontario; A. C. Thoresen, McMinnville, Oregon; S. P. Vander Kloet, Acadia University, Wolfville, Nova Scotia.

I am also indebted to the President of the Ottawa Field-Naturalists' Club Gary McNulty and the Club Council for continuing support of the journal; Chairman Ron Bedford and the Publications Committee of the OFNC for editorial encouragement and support, to the Canadian Museum of Nature for access to its library and the facilities at the Natural Heritage Building, 1740 Pink Road, Gatineau [Aylmer sector], Quebec, and to Joyce for everything else.

FRANCIS R. COOK
Editor

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ISSN 0008-3550

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The CANADIAN FIELD-NATURALIST

Published by THE OTTAWA FIELD-NATURALISTS' CLUB, Ottawa, Canada

Volume 119, Number 3

July–September 2005

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The Canadian Field-Naturalist

The *Canadian Field-Naturalist* is published quarterly by The Ottawa Field-Naturalists' Club. Opinions and ideas expressed in this journal do not necessarily reflect those of The Ottawa Field-Naturalists' Club or any other agency.

PAP Registration Number 9477. Canada We acknowledge the financial support of the Government of Canada through the Publication Assistance Program (PAP) toward our mailing costs.

All manuscripts intended for publication except Book Reviews should be addressed to the Editor and sent by postal mail. Book-review correspondence should be sent by e-mail or postal mail to the Book-review Editor.

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COVER: The small remnant peatland on the shore of Black Lake, Gatineau Park, Quebec, twenty-six years after being flooded by Beavers, *Castor canadensis*. (Photograph by Joyce Reddoch, taken on 3 July 2006.) See the paper on the consequences of flooding on a small shore fen by J. M. Reddoch and A. H. Reddoch, pages 385-394.

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The Canadian Field-Naturalist

Volume 119, Number 3 July–September 2005

An Analysis of the Parasites of a Mid-winter Population of the Snowshoe Hare, *Lepus americanus,* on Insular Newfoundland During a Cyclical Peak

K. E. Bennett[1], E. M. Baggs[2], J. R. Finney-Crawley, and M. McGrath[3]

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Bennett, K. E., E. M. Baggs, J. R. Finney-Crawley, and M. McGrath. 2005. An analysis of the parasites of a mid-winter population of the Snowshoe Hare, *Lepus americanus,* on insular Newfoundland during a cyclical peak. Canadian Field-Naturalist 119(3): 323-329.

A mid-winter sample of 78 Snowshoe Hares *(Lepus americanus)* was collected during their cyclical peak in population from three eco-regions (Western Newfoundland, North Shore and Avalon Forest) on insular Newfoundland and was examined for the presence of enteric parasites. The length of the hares was significantly shorter in the Avalon Forest Region (n = 27) than those of the Western Newfoundland Region (n = 25) and North Shore Region (n = 26) samples ($P \leq 0.001$ and $P \leq 0.003$ respectively); however, no significant differences occurred for other morphological measurements. Four species of parasites, two cestodes (*Mosgovoyia pectinata* and *Taenia pisiformis*) and two nematodes (*Obeliscoides cuniculi* and *Rauschia triangularis*), were recovered. *Taenia pisiformis* was recovered from the North Shore eco-region only. No other significant differences with respect to their prevalence, intensity, mean intensity, relative density and dispersion between eco-regions were found. Within eco-regions, only *R. triangularis* showed a significantly higher value ($P \leq 0.027$) for males and the prevalence of this species was lower than that previously reported. The occurrence of *O. cuniculi* was significantly different between the higher weight classes of hares and the prevalence of this species was higher than that previously reported. No trends for multiple infections were noted. The expansion of a new animal species, the Coyote, *Canis latrans,* to Newfoundland appeared to have had no effect on the diversity of parasites found in the hare.

Key Words: *Lepus americanus,* Snowshoe Hare, parasite diversity, cestodes, *Mosgovoyia pectinata, Taenia pisiformis,* nematodes, *Obeliscoides cuniculi, Rauschia triangularis,* eco-regions, exotics, insular Newfoundland.

Following the Wisconsinian glaciation, the mammalian fauna of insular Newfoundland was impoverished (Dodds 1957 Scruton et al. 1995) and the island had a high predator to prey species ratio. Much of the present biodiversity is a result of accidental or deliberate introductions and colonization. The original small mammal (prey) populations consisted of the Arctic Hare (*Lepus arcticus*) and the Meadow Vole (*Microtus pennsylvanicus*) while the mammalian predator list consisted of the Lynx (*Lynx canadensis*), Black Bear (*Ursus americanus*), Newfoundland Wolf (*Canis lupus beothucus,* now extinct), Red Fox (*Vulpes vulpes*), and a variety of mustelids; i.e., the Pine Marten (*Martes americana*), Short-tailed Weasel (*Mustela erminea*), and River Otter (*Lutra canadensis*). There have also been temporary invasions of the Arctic Fox (*Alopex lagopus*) (Banfield 1987).

Over the last 150 years there have been a number of deliberate introductions that have resulted in successful establishment of populations in insular Newfoundland. These included the Snowshoe Hare (*Lepus americanus*) in 1864 and Moose (*Alces alces*) in 1904 (Banfield 1987), which were introduced as a means of increasing the availability of fresh meat to the resident human population. Small mammal introductions of the Red Squirrel (*Tamiasciurus hudsonicus*) in 1963 (Payne 1976) and Eastern Chipmunk (*Tamias striatus*) in 1962 (Northcott et al. 1973) were made to enhance the small mammal prey base of the island. The Deer Mouse (*Peromyscus maniculatus*), introduced in 1968 (Gould and Pruitt 1969), is thought to have been accidental, imported with cargo shipped through the Maritime provinces of Canada to Newfoundland. The Red-backed Vole (*Clethrionomys gapperi*) (first recorded about 1997 but precise year of introduction unknown) remains an enigma. It has been suggested that it established populations in the Stephenville area and elsewhere on the island and may have originated

from transportation of logs to the liner board mill in Stephenville from Labrador from as far back as the late 1960s. Shipments of these logs were sporadic over that period. The Masked Shrew (*Sorex cinereus*) was introduced in 1958 in an attempt to control outbreaks of the Hemlock Looper (*Lambdina fiscellaria*) (Warren 1970). The carnivore list increased in May 1987 when the Eastern Coyote (*Canis latrans*) became well-established after crossing the Gulf of St. Lawrence on winter ice floes from the Maritimes (Parker 1995).

Introductions of exotic animals have the inherent risk of bringing accompanying parasites and/or pathogens which may subsequently impact on resident species. Dodds and Mackiewicz (1961) examined 630 Snowshoe Hares in an attempt to establish the parasite fauna of these herbivores in Newfoundland and reported the following enteric parasites: trematode: *Dicrocoelium dentriticum;* cestodes: *Mosgovoyia pectinata, Hydatigera taeniaeformis, Multiceps* sp. and *Taenia pisiformis;* nematodes: *Trichostrongylus axei* and *Obeliscoides cuniculi.* Smith and Threlfall (1972) examined three Snowshoe Hares and reported the presence of the cestodes *Multiceps serialis* and *Taenia pisiformes* in the coelomic cavities, the nematode *Rauschia triangularis* in the digestive tract, and an unidentified nematode from the lungs. While there is no information on the parasite burdens of the Snowshoe Hares used in the 1864 introductions, the work of Dodds and Mackiewicz (1961) and Smith and Threlfall (1972) form a basis from which a comparison of the Snowshoe Hare parasites may be made in light of subsequent mammalian introductions. This paper examines the mid-winter enteric parasite standing of *Lepus americanus* from insular Newfoundland collected during the hare cyclical peak (Reynolds et al. 2004*).

FIGURE 1. Map of insular Newfoundland, Canada. Collection Areas 1, Western Newfoundland, (57°45'W, 49°6'N), 2, North Shore (53°53'W, 48°41'N), 3, Avalon Forest (53°12'W, 47°30'N).

Materials and Methods

A total of 78 adult Snowshoe Hares was collected by shooting and snaring by hunters and trappers from three eco-regions (Figure 1): Western Newfoundland (Eco-region 1), Sub-region 1a – Old Man's Pond (n = 25); North Shore (Eco-region 3) (n = 26) and Avalon Forest (Eco-region 5) (n = 27) of insular Newfoundland (Meades and Moores 1994) and were submitted to the Inland Fish and Wildlife Division of the Government of Newfoundland and Labrador. The three eco-regions have similar populations of plants and animals but differ in physical attributes and land usage. Collections were carried out during January through February 2000 at the cyclical peak for Snowshoe Hares (Reynolds et al. 2004*) in Newfoundland. Morphological criteria were obtained prior to necropsy. Hares were examined for helminth parasites using conventional parasitological techniques. Descriptive statistical analysis of hare morphology, parasite parameters or both was accomplished using the Microsoft Excel 98 statistical package. A comparison of body length-weight relationship was carried out using the general linear model and a comparison of the slopes was made to determine whether the growth curves differed by eco-region. Comparisons of hare population data were carried out using standard paired t-tests and one-way ANOVAs. Comparisons of hare data based on sex were carried out using Mann-Whitney and Kruskall-Wallis non-parametric tests. Parasite parameters (i.e., prevalence, abundance etc.) were determined using the methods of Margolis et al. (1982).

Data for all parasites except *Rauschia triangularis* were based on counts, but, due to the large numbers observed, values for *R. triangularis* were ranked. In all cases this parasite exceeded 50 individuals and a scale of 0 through 3 was used to rank estimated population numbers (i.e., 0 = 0 parasites, 1 = 1 – 50 individuals, 2 = 50 – 100 parasites and 3 = more than100 individuals).

Results

The Snowshoe Hares had an overall sex ratio of 1.1: 1.0 (males: females). Based on weight, there were no significant differences between animals from the three eco-regions (Table 1). There were no differences between the body length of North Shore and Western Newfoundland hares; however, those of the Avalon Forest were significantly shorter ($P \leq 0.001$ and $P \leq 0.003$ from North Shore and Western Newfoundland). There was a trend for the hares to be longer on an east to west basis by eco-region, although no significant differences were noted for any other physical characteristic measured. No significant differences were found in body length-weight relationships ($P = 0.05$) and the subpopulations were considered similar.

TABLE 1. Summary of morphometric data (means) on *Lepus americanus* from three Eco-regions on insular Newfoundland: Western Newfoundland, North Shore and Avalon Forest.

Parameter	Ecoregion		
	Western Newfoundland (57°45'W, 49°6'N)		
	Male (n = 12)	Female (n = 12)	Total (n = 24)
Weight (kg) (± SD)	1.35 ± -0.134	1.46 ± -0.125	1.405 ± -0.138
Length (mm)	442.8 ± -21.70	453.3 ± -11.02	448.05 ± -17.66
L H F L (mm s.u.[1])	127.7 ± -4.73	125.9 ± -4.50	126.8 ± -4.62
Pinnae (mm)	87.2 ± -3.75	85.8 ± -4.43	86.5 ± -4.24
Slot (mm)	70.3 ± -2.53	70.4 ± -4.06	70.35 ± -3.31
	North Shore (53°53'W, 48°41'N)		
	Male (n=13)	Female (n=12)	Total (n=25)
Weight (kg) (± SD)	1.34 ± -0.174	1.44 ± -0.133	1.39 ± -0.161
Length (mm)	440.8 ± -15.77	450.6 ± -14.95	445.70 ± -15.86
L H F L (mm s.u.[1])	122.4 ± -5.88	127.2 ± -16.06	124.80 ± -11.72
Pinnae (mm)	87.5 ± -5.06	89.9 ± -3.29	88.7 ± -4.38
Slot (mm)	71.7 ± -5.41	73.4 ± -3.12	72.55 ± -4.45
	Avalon Forest (53°12'W, 47°30'N)		
	Male (n=14)	Female (n=13)	Total (n=27)
Weight (kg) (± SD)	1.35 ± -0.114	1.41 ± -0.145	1.38 ± -0.130
Length (mm)	426.7 ± -25.92	429.9 ± -21.55	428.30 ± -23.52
L H F L (mm s.u.[1])	124.8 ± -6.86	125.5 ± -9.79	125.15 ± -8.24
Pinnae (mm)	86.8 ± -6.22	88.1 ± -6.28	87.45 ± -6.16
Slot (mm)	72.0 ± -2.33	68.5 ± -4.32	70.25 ± -3.65

[1]L H F L – Left Hind Foot Length; s.u. – *sans ungus*

TABLE 2. Occurrence of the parasites of *Lepus americanus* from three Eco-regions on insular Newfoundland: Western Newfoundland, North Shore and Avalon Forest. + = present; – = not present

Parasite	Ecoregion		
	Western Newfoundland	North Shore	Avalon Forest
Mosgovoyia pectinata	+	+	+
Taenia pisiformis	-	+	-
Obeliscoides cuniculi	+	+	+
Rauschia triangularis	+	+	+

Sixty percent of the hares contained at least one parasite species, 25.6 percent contained two parasite species and 3.8 percent contained three parasite species. No hares contained four parasite species and 10.3 percent of the hares contained no enteric parasites.

Four enteric parasite species were recovered. Two cestodes: adult *Mosgovoyia pectinata* and the cysticercus *Taenia pisiformis* and two nematodes: *Obeliscoides cuniculi* and *Rauschia triangularis* (Table 2). *Taenia pisiformis* occurred in one female hare in the North Shore Eco-region whereas *M. pectinata* and the two nematodes *O. cuniculi* and *R. triangularis* occurred in all three eco-regions. The parasite parameters for *Lepus americanus* from the three eco-regions are shown in Table 3. There were no significant differences ($P = 0.05$) for *M. pectinata* by sex within or between eco-regions. This was also the case for *O. cuniculi. Raushia triangularis* showed significantly higher ($P \leq 0.027$) values for males in the North Shore by sex, however, no differences existed on an eco-regions basis ($P \geq 0.05$).

An evaluation of parasite prevalence etc., for all the hares based on weight categories (Table 4) showed no significant difference ($P = 0.05$) between hare weight classes in infections of *Mosgovoyia pectinata* and *Rauschia triangularis.* Infections with *Obeliscoides cuniculi* showed significant differences between weight class 1.32 to 1.48 kg and 1.64 to 1.80 kg ($P \leq 0.04$) and between weight class 1.48 to 1.64 kg and 1.64 to 1.80 kg

TABLE 3. Parasite parameters for *Lepus americanus* from three Eco-regions on insular Newfoundland: Western Newfoundland, North Shore and Avalon Forest.

Species	W. NF (n=25)	N. Shore (n=26)	Av. For. (n=27)	Total (n=78)
		Prevalence		
M. pectinata	0.040	0.192	0.037	0.090
T. pisiformis	0.000	0.038	0.000	0.013
O. cuniculi	0.350	0.846	0.741	0.654
R. triangularis	0.440	0.423	0.593	0.48
		Intensity		
M. pectinata	1	1-6	2	1 - 6
T. pisiformis	0	1	0	1
O. cuniculi	1 - 189	1-237	1 - 78	1 - 237
R. triangularis	3*	3*	3*	3*
		Mean Intensity		
M. pectinata	1.000	2.500	2.000	2.170
T. pisiformis	0.000	NA	0.000	NA
O. cuniculi	29.78	29.00	32.40	28.82
R. triangularis	NA	NA	NA	NA
		Relative Density		
M. pectinata	0.040	0.480	0.074	0.195
T. pisiformis	0.000	NA	0.000	NA
O. cuniculi	10.72	24.53	24.00	18.84
R. triangularis	NA	NA	NA	NA
		Dispersion		
M. pectinata	1.000	3.970	2.000	
O. cuniculi	134.99	107.38	25.84	

NOTE: In all cases counts for *Rauschia triangularis* exceeded 50 individuals.

W. NF – Western Newfoundland
N. Shore – North Shore
Av. For. – Avalon Forest
3* sample has greater than 100 parasites
NA – not applicable

($P \leq 0.03$), the majority of the parasites occurring in the smaller hares. The largest of the hares (n = 3) had the least number of parasites.

In the smaller hares, there is a tendency for *Rauschia triangularis* to occur at a higher prevalence than *Obeliscoides cuniculi* whereas the reverse is seen for the heavier two weight classes (Table 4).

Discussion

The most extensive study of the parasites of *Lepus americanus* on the island of Newfoundland (Dodds and Mackiewicz 1961) involved collections of hares from 1954 through 1959. Of a total of 630 hares they examined, 483 were collected from the Humber East, White Bay South, St. Barbe and Grand Falls districts. The remaining 147 were collected from Emberly Island in Placentia Bay, Newfoundland, a population that was established in 1954 using hares from the main island. Smith and Threlfall (1972) reviewed the parasites of only three adult hares originating from the Avalon Peninsula of Newfoundland.

Our study differs from Dodds and Mackiewicz (1961). They reported on hares from different seasons and years and for juveniles and adults. Our study used hares captured during mid-winter (January/February) and examined adults only. While containing host specimens from the same area as that evaluated by Dodds and Mackiewicz (1961), it extends the geographic coverage of the island by sampling the eastern portion of the province.

The four parasite species recovered in this study were the same as previous studies in the area. Dodds and Mackiewicz (1961) found that the prevalence of the cestode *Mosgovoyia pectinata* varied over four years starting with 7% prevalence in 1956, rising to a high of 36% in 1958, and dropped to 4% in 1959. The high values found in 1958 occurred during the cyclical

TABLE 4. Parasite parameters for *Lepus americanus* from insular Newfoundland placed in five weight classes.

	Weight Class (kg)				
	1.00-1.15 (n = 5)	1.16-1.32 (n = 18)	1.33-1.48 (n = 33)	1.49-1.64 (n = 17)	1.65-1.80 (n = 3)
Species			Prevalence		
M. pectinata	0.04	0.05	0.03	0.06	0.00
T. pisiformis	0.00	0.00	0.63	0.76	0.00
O. cuniculi	0.60	0.61	0.39	0.53	0.06
R. triangularis	0.80	0.81	0.12	0.00	0.12
			Intensity		
M. pectinata	2	6	1	1	0
T. pisiformis	0	0	0	3*	0
O. cuniculi	17-237	1-58	1-189	1-78	8
R. triangularis	3*	3*	3*	3*	3*
			Mean Intensity		
M. pectinata	2	6	1	1	0
T. pisiformis	0	0	0	NA	0
O. cuniculi	105.67	20.82	28.52	22.46	0.47
R. triangularis	NA	NA	NA	NA	NA
			Relative Density		
M. pectinata	0.80	0.33	0.03	0.12	0.00
T. pisiformis	0.00	0.00	0.00	NA	0.00
O. cuniculi	63.4	12.72	18.15	17.18	0.47
R. triangularis	NA	NA	NA	NA	NA
			Dispersions		
M. pectinata	1.5	6.00	1.00	0.94	NA
T. pisiformis	NA	NA	NA	NA	NA
O. cuniculi	159.02	22.28	90.43	29.08	8.00
R. triangularis	NA	NA	NA	NA	NA

3*– sample contains more than 100 parasites

Note – The sample size (n = 76) for weights is less than the total (n = 78) used for parasites due to heads of the hares being missing in two samples.

decline in hare populations and were from juveniles only; adults did not contain this parasite. Dodds and Mackiewicz (1961) reported that their juveniles often presented distended small intestines which appeared to be occluded, although the hares otherwise appeared to be in good condition. In contrast, the 8% prevalence for *M. pectinata* in our study was for adults taken in mid-winter only and no significant differences in prevalence were found between weight classes (Table 4) of the hares. There were no indications of occlusions or organ damage and the hares appeared to be in excellent condition.

The cysticerci of *Taenia pisiformis* were recovered from only one female hare in the North Shore Ecoregion, however, four out of six specimens of hares snared in the Avalon Forest Eco-region in 2001 contained massive infections of *T. pisiformis* (E.M.B.). Dodds and Mackiewicz (1961) report relatively heavy prevalences for *T. pisiformis* and *Hydatigera taeniaeformis* and lump the data to show prevalences which range from a high of 61% in 1956 to a low of 17% in 1958. We found no indication of *H. taeniaeformis* in this study. The rarity of *T. pisiformis* could be related to the scarcity of canids in the respective eco-regions as the definitive hosts for this parasite are known to be canids (i.e., Red Fox, Coyote and Domestic Dog) (Whitney 2000*). However, the eco-regions utilized in this study are areas where active trapping of furbearers takes place and during peak years of the hare cycle, there may be a dilution effect such that the definitive host populations would be low relative to the intermediate host population. Winter conditions would remove the hares from normally exposed vegetation on which tapeworm eggs would be deposited and coupled with higher mortality of such eggs, a loss in parasites could be expected. These low numbers could also be a result of conferred immunity from earlier infections. Heath (1973) showed immunity to *T. pisiformis* eggs in New Zealand White Rabbits following injections with antigens from various stages of parasite development (i.e., oncospheres, larvae, etc.). Rickard and Coman (1977) further demonstrated that immunity and enhanced development of *T. pisiformis*

in New Zealand White Rabbits depending on which species of *Taenia* was utilized as the antigenic source.

Obeliscoides cuniculi was more prevalent (65%) than any of the values reported by Dodds and Mackiewicz (1961). They reported a prevalence of 44% in 1956 rising to a high of 63% in 1958, subsequently dropping to 54% in 1959. Most of their hares were obtained during the summer of a cyclical peak in population. Erickson (1944) also reports the highest frequency for this parasite at the beginning of a decline in hare numbers. The values for *O. cuniculi* in this study mirror the findings of Erickson (1944). Keith et al. (1985) report significantly higher values ($P = 0.07$ and $P = 0.02$) for this parasite during mid-winter and during repetitive cyclical peaks in 1962 and 1971 respectively. Keith et al. (1985) attribute the higher numbers of the winter populations of *O. cuniculi,* to the rise in the pituitary gonadotrophins and testicular weights prior to the March breeding season. The cyclical increases in *O. cuniculi*, which co-occur with the rise in Snowshoe Hare populations, are probably reinforced through density effects, where large numbers of hares are feeding in restricted habitats.

For all parasites except *Rauschia triangularis* there were no significant ($P \geq 0.05$) differences between eco-regions or between sexes. *Rauschia triangularis* had a significantly higher ($P \leq 0.027$) abundance of parasites in males over females from the North Shore Eco-region. No other differences occurred for this parasite at the other eco-regions. We can offer no explanation for this. Erickson (1944) reports no significant difference between sexes for *R. triangularis* but does indicate that different areas may yield different prevalences for the parasite. He also found a high prevalence during late winter.

An evaluation of the parasite standings based on weight increments for the entire population studied showed no significant differences ($P \geq 0.05$) between weight classes in regards to *Mosgovoyia pectinata* and *Rauschia triangularis* (Table 4).Our results show that a significant majority ($P \leq 0.04$) of *Obeliscoides cuniculi* occur in the smaller hares. This differs from Keith et al. (1986), who report consistently higher values in adult hares during December-April ($P < 0.001$). As in our study, they did not show significant differences between sexes. Results similar to this study and Keith et al. (1986) are shown in Erickson (1944) and Keith et al. (1985). There is a tendency for *R. triangularis* to have a higher prevalence over *O. cuniculi* in the smaller hares, a situation similar to that reported by Keith et al. (1986) who reported a higher prevalences of *R. triangularis* ($P = 0.059$) among juveniles. Conversely, the larger hares contained significantly greater numbers ($P < 0.001$) of *O. cuniculi* over *R. triangularis* as is seen in Keith et al. (1986).

An evaluation of multiple infections showed no apparent trends in the parasite burdens of males or females. Sixty percent of the hares contained at least one species of parasite, 25.6 two, and 3.8 three; 10.3 percent none. Dodds and Mackiewicz (1961) report greater parasite diversities in their study. The trematode *Dicrocoelium dentriticum* and the nematode *Trichostrongylus axei,* which were reported from Emberly Island in Placentia Bay, are normally considered parasites of sheep and other ruminants. This island was used extensively for sheep grazing by residents and it appeared that the hares were paratenic (non specific or reservoir) hosts. Recent studies (in preparation) indicate the presence and spread of new parasites within ungulates and insectivores which are attributed to the Coyote range expansion; however, no new parasites appear to have spread to the Snowshoe Hare from any of the recently (i.e., less than fifteen years) established non-native mammals.

Acknowledgments

We thank Mike McGrath, Senior Small Game and Furbearer Biologist, Inland Fish and Wildlife Division, Department of Tourism, Culture and Recreation, Government of Newfoundland and Labrador, St. John's, Newfoundland, and the hunters and trappers who obtained the specimens utilized in this study.

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Received 8 April 2002
Accepted 24 August 2005

Reconstructing Changes in Abundance of White-tailed Deer, *Odocoileus virginianus,* Moose, *Alces alces,* and Beaver, *Castor canadensis,* in Algonquin Park, Ontario, 1860-2004

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Quinn, Norman W. S. 2005. Reconstructing changes in abundance of White-tailed Deer, *Odocoileus virginianus*, Moose, *Alces alces,* and Beaver, *Castor canadensis,* in Algonquin Park, Ontario, 1860–2004. Canadian Field-Naturalist 119(3): 330–342.

The history of White-tailed Deer, *Odocoileus virginianus,* Moose, *Alces alces,* and Beaver, *Castor canadensis,* in Algonquin Park since the1860s is reviewed and placed in the context of changes to the forest, weather, and parasitic disease. Deer seem to have been abundant in the late 1800s and early 1900s whereas Moose were also common but less so than deer. Deer declined through the 1920s as Moose probably increased. Deer had recovered by the 1940s when Moose seem to have been scarce. The deer population declined again in the 1960s, suffered major mortality in the early 1970s, and has never recovered; deer are essentially absent from the present day Algonquin landscape in winter. Moose increased steadily following the decline of deer and have numbered around 3500 since the mid-1980s. Beaver were scarce in the Park in the late 1800s but recovered by 1910 and appear to have been abundant through the early 1900s and at high numbers through mid-century. The Beaver population has, however, declined sharply since the mid-1970s. These changes can best be explained by the history of change to the structure and composition of the Park's forests. After extensive fire and logging in the late 1800s and early 1900s, the forest is now in an essentially mature state. Weather and parasitic disease, however, have also played a role. These three species form the prey base of Algonquin's Wolves, *Canis lycaon,* and the net decline of prey, especially deer, has important implications for the future of wolves in the Park.

Key Words: Algonquin Park, Moose, *Alces alces,* Deer, *Odocoileus virginianus,* Beaver, *Castor canadensis,* Wolves, *Canis lycaon,* ticks, *Dermacentor*, Ontario.

The biota of Algonquin Provincial Park, Ontario, have been under study since the mid-1930s and much information on fish and wildlife resources has accumulated since that time. There are, in addition, anecdotal records of the Park's major fauna from as early as the 1860s. There are particularly useful, if at times sporadic, data on White-tailed Deer (*Odocoileus virginianus*), Moose (*Alces alces*), and Beaver (*Castor canadensis*). Fluctuations in abundance of these species can be related to long-term change to structure and composition of the Park's forests which, in qualitative terms at least, is well known (Strickland 1993). Recently, concern has been raised about the status of Wolves (*Canis lycaon*) in Algonquin Park (Theberge 1998). Moose, White-tailed Deer, and Beaver collectively form the prey of Algonquin's Wolves (Pimlott et al. 1969; Voigt et al. 1976; Forbes and Theberge 1992; Forbes and Theberge 1996) and, ultimately, the fate of the Wolf population will depend on the status of these prey species. This paper is a review of the long-term history of Moose, White-tailed Deer, and Beaver in Algonquin Park.

Methods

The information presented in this paper from prior to about 1940 is essentially anecdotal. Post-1940, the data are from a mix of anecdotal references and population surveys, with formal surveys coming to dominate since about the 1960s. The "historic" information (pre-1940) is largely from land surveyors' reports and annual reports of the Park Superintendent to the Minister responsible for Crown land. Post-1940 the data are from a variety of sources including annual reports of the Department of Lands and Forests (which became the Ministry of Natural Resources (O. M. N. R.) in 1972) which often featured Algonquin Park, unpublished reports from staff who worked at the Park's Wildlife Research Station, and, increasingly with time, published research papers.

From about the mid-1950s the population surveys developed into standardized techniques accepted across the province. For Moose, this involved the gradual application of plot-based mid-winter aerial surveys that began in Ontario in about 1950 and have evolved into a formalized provincial survey technique (Bisset 1996*). The currently accepted technique came into more or less its current form in the mid-1970s, but aerial survey data are reported here from 1950, the earlier surveys being somewhat less rigorous in design.

Epizootics of Winter Tick, *Dermacentor albipictus,* can cause severe die-offs of Moose (Blyth and Hudson 1987). In the early 1980s, E. Addison established a technique to assess the severity of tick infestation by modification of a "hair loss index" first developed in Alberta (Samuel and Barker 1979). The technique measures the extent of hair loss that is apparent on

FIGURE 1. Algonquin Park, showing the location of wilderness zones, historic deer yards, principal Beaver survey transects, and the east-west division of forest types.

Moose in late winter. A survey is flown by helicopter on one day from 20-25 March in an approximately 2000-km^2 zone in the south-center of the Park to place at least 40 Moose in the five categories of hair loss proposed by Samuel and Barker. A simple arithmetic index, the Hair Loss Severity Index (H. S. I.), is then calculated by multiplying the number of Moose in each category by its severity rank (1-5), summing this, and dividing by the total Moose observed. The H. S. I. is used to predict the extent of mortality the following spring.

Deer are much more difficult to census than Moose and have generally been surveyed by counting droppings or "pellet groups", a technique that was first employed in the U. S. in about 1940 (Bennet et al. 1940) and came into use in Ontario shortly afterwards. The technique was first applied in Algonquin Park in the mid-1950s and a protocol was developed that was used throughout south-central Ontario into the mid-1970s (Anonymous 1980*). These pellet group surveys provide the best reference to deer populations in the Park. As will be shown, the Park's deer population declined drastically in the early 1970s and the technique, which is difficult in even ideal conditions and unreliable at low deer densities, was abandoned.

Since the early 1970s deer surveys in the Park have consisted of late-winter aerial surveys of historic deer wintering areas ("yards"). Eight deer yards, some greater than 10 000 ha, were located across the Park (Figure 1) and supported high densities of deer (e.g., Stanfield 1957*) through mid-century. Several of these yards were surveyed in each of 1985, 1989, 1994, 2000, 2001, and 2004. Every yard was flown at least once in the years listed and most were flown several times. The 2004 survey included several areas in the south-center of the Park that were outside the historic yards but with potentially good winter cover. The surveys were done in mid- to late March when snow is deepest. North-south transects were flown at 1 km intervals with fixed wing aircraft at approximately 140-km/h airspeed and deer tracks and trails tallied along the transects. In addition, deer sign was recorded during an aerial Wolf survey from 6-23 February 2002 (Patterson et al. 2004). Fifty-one hours were flown in a Bell 204 helicopter at approximately 100 m over 44 5×5 km survey plots. Many of these plots were located in the historic yards and nearly all had at least some coniferous cover potentially suitable for deer.

Since 1955, Beaver have been surveyed in the Park by counting live colonies along aerial survey transects. The surveys have generally been done in late October after leaf fall but before ice-up when Beaver are actively storing food and evidence of fresh cutting (i.e., food piles) can be readily observed from the air. Results have been expressed as live colonies per unit area. There have been several different types of surveys and results of essentially all are reported here. The best data are from a long series of a survey first done in 1960 by Rod Stanfield that consisted of two transects that each formed a circuit around the Park (a short segment of each flight was outside the Park, Figure 1). The survey was flown at a constant height of 800 feet by reference to points of elevation along the transects, and the observers line of sight established through a wing strut so that an observed band of 3200 feet was centered on the transect. Smith (1969*) summarized these data from 1960 – 1968. Stanfield described his survey technique, including the "way points" at the end of each transect, precisely, so that the survey can be repeated accurately. E. Addison reviewed and reinstated the survey in 1998 (Addison 1998*) and the survey was flown again in 1999 and 2003.

Further information on specific survey methodologies can be found in the papers cited above. Unpublished works and much of the original data for surveys referred to throughout this paper are found either in the O. M. N. R. Research Library in Peterborough, Ontario, or the Archives of Algonquin Park.

Winter severity is a key factor in the productivity and survival of deer (e.g., Mech et al. 1987) and very severe winters can result in mortality of Moose (Bishop and Rausch 1974). Historic records of winter weather are presented and related to trends in abundance of deer. Monthly means of temperature were obtained from the Ontario Climate Center of Environment Canada in Downsview, Ontario, for Algonquin Park (Park Headquarters at Cache Lake) from 1917 to 1972 and Dwight, Ontario, from 1973 to 2002 (the weather station was closed in the Park in 1973; Dwight is 20 km west of the Park boundary). Snow accumulation was obtained from a snow depth station that has been operating at the Park's west gate since 1952.

Forest management is also a key influence on all three species (e.g., Monthey 1984; Novak 1987; Peek 1998). An overview of the history of logging and fire suppression in the Park is given in the next section before results of the various surveys are presented.

Results

History of Logging and Fire Suppression

Algonquin Park is 7600 km^2 and is a multiple-use Park consisting of a complex array of zones in which varying degrees of activity are permitted. Complete protection is afforded to Wilderness Zones (Figure 1) but commercial logging is permitted in the Recreation-Utilization Zone, which comprises 78% of the Park. However, with various reserves of land for, for example, shoreline protection, only about ⅔ of the landbase is available for logging. This zoning system was established in the Master Plan of 1974 (Anonymous 1974*) and has been affirmed by Management Plans since then (Anoymous 1998*).

The Park actually consists of two forests; the eastern third of the Park consists essentially of pine forests, primarily White Pine, *Pinus strobus,* with lesser amounts of Red Pine, *Pinus resinosus,* and isolated Jack Pine, *Pinus banksiana,* stands on well-drained, sandy outwash and rolling to flat terrain. The remaining two thirds, approximately 4600 km^2 of the Park's west side, consists of tolerant hardwood forest: Sugar Maple, *Acer saccharum,* American Beech, *Fagus grandifolia,* Yellow Birch, *Betula alleghaniensis,* and Hemlock, *Tsuga canadensis,* on glacial till over poorly-drained rugged terrain (Figure 1).

As early as the 1830s (Strickland 1993) loggers entered the Park seeking White and Red pine "square timber" coincident with the removal of pine across northeastern North America at the time (Runkle 1985; Abrams and McCay 1996). Logging progressed rapidly up the main waterways of the Park; by 1866-67, 30 000 pieces of square timber were removed annually (Strickland 1993). The square timber activity had peaked about 1864 and declined thereafter, the last square timber being cut in 1912 (Anonymous 2000*). White Pine, however, remained the focus of interest as sawmills appeared before the square timber period ended.

It seems that the removal of pine was extensive, nearly complete in places. Recent work analyzing remnant pine stumps (the fine remains of which can persist more than 120 years) suggests that 70 – 94% of the pine was removed from hardwood forests in the south-center of the Park (Simard 2001). The debris left from this logging fostered extensive fires primarily in the east-side pines (Fitzgerald 1890*, and see historic notes in Runge and Theberge 1974). Fires were frequent into the early 1900s although Superintendent G. W. Bartlett noted in several of his annual reports that these fires were "generally brought under control" (Bartlett 1905-1921*).

By the 1930s attention turned to hardwoods, in part because the pine had been depleted but also because of the development of new markets, including Yellow Birch veneers for construction of the Mosquito fighter-bomber of World War 2 (Anonymous 2000*). Remnant stands were often logged over for pulp (Runge and Theberge 1974). Fire apparently remained common until the early 1930s (Robinson 1933).

Hard data on the extent of the removal of forest cover from all this activity is lacking but it appears that it was, in places at least, extensive. Photos exist from the late 1800s and early 1900s showing barren hillsides in the Park (Algonquin Park Museum Archives). White-tailed Deer, Moose, and Beaver are fundamentally adapted to early successional habitats (Novak 1987;

Voigt et al. 1997; Peek 1998) and, from the point of view of food supply at least, habitat was probably favourable for all three species through the first half of the 1900s. Hall (1971), for example, noted that by 1893 the logging of White Pine in Algonquin Park had been underway for 50 years and "considerable areas of the Park were undoubtedly in the secondary stages of forest succession that provide good beaver habitat". Stephenson and Hepburn (1958*) reported that continued logging since the 1800s had brought a "succession of areas" into a good productive state for deer.

The harvest of Yellow Birch was gradually supplanted by Sugar Maple, the primary use of which has shifted over time from sawlogs to pulp (Anonymous 2000*). Hemlock, which is excellent winter cover for deer (Voigt et al. 1997), was not a priority species historically, nor is it today, but it was harvested in the late 1800s and early 1900s in the southwest of the Park for the tan bark industry (Strickland 1993) and then extensively in the 1960s for shoring timber, principally to build the Toronto subway (Wilton 1987). Wilton reported that 203 456 acres (82 339 ha) were cut over in six of the historic deer yards in the Park from 1952-1971. He pointed out that, although this created regeneration for browse, "large volumes" of coniferous cover, particularly of Hemlock, were removed to the detriment of deer (Wilton 1987). M. Robinson made the same point in 1933, suggesting that "many of the former yarding grounds have been destroyed by lumbermen removing the spruce, pine, and hemlock" (Robinson 1933).

As early as the late 1930s (Runge and Theberge 1974) and definitely by the early 1950s (Anonymous 2000*) diameter limit harvesting began to replace the more or less unregulated cutting. This evolved into partial cutting systems; the single-tree selection system, which was first employed in the late sixties in the hardwoods, and "uniform shelterwood" harvest in the pine stands on the east side.

Selection cutting, which has been applied across the western ⅔ of the Park since the 1960s (Strickland 1993; Anonymous 2000*), retains a more or less intact forest canopy. Partial cutting systems can produce a considerable shrubby understory (Kelty and Nyland 1983) that is frequently renewed because stands are "treated" every 20-25 years. However, selective logging does not produce the biomass of browse that more aggressive logging systems do (e.g., Monthey 1984) and biologists in Ontario do not consider it of optimal benefit to browsers like deer (Voigt et al. 1997). Research on the effects of pine uniform shelterwood on ungulates is lacking but the system is normally effective at regenerating White Pine (Anonymous 2000*) that grows to dominate the understory and thus may not produce large quantities of palatable browse.

Forest fire is not normally active in mature tolerant, or "Northern", hardwood forest found on the Park's west side (e.g., Lorimer and Frelich 1994) and must have become less frequent as the forest recovered. Fire, on the other hand, is naturally very frequent in the Park's east side pines (Cwynar 1978). Fire was, at any rate, gradually eliminated from the landscape more or less coincident with the shift to low-impact logging. The introduction of fire towers and "fire ranging" aircraft in the late 1920s began a process that rapidly brought down the area of forest burned annually (Runge and Theberge 1974). Forest fire has been under essentially complete control in the Park for decades; although there are approximately two dozen lightning "starts" each year, fires rarely get past one hectare in size (Anonymous 2000*).

Today, as a result of the elimination of fire and evolution to selection logging, the Park's forests are in an essentially mature state. Seventy-seven percent of the Park's hardwood zone is in mature tolerant hardwoods and the rest is in "static" wetland (e.g., Black Spruce, *Picea mariana*) or swamp hardwood forest, or mature intolerant hardwoods that are succeeding to Maple-Beech (Quinn 2004). The east-side pine forests are also primarily mature or uneven-aged (Anonymous 2000*). The 22% of the Park that is in protected zones and has not been logged since at least the 1960s is also essentially mature forest, and, in places, approaching "old growth" (as defined by Keddy 1994 and Tyrell and Crow 1994).

In summary, the Park's forests were extensively disturbed in the late 1800s and early 1900s but recovery began in the 1930s with the suppression of fire and adoption of low impact logging techniques. It is widely accepted that the recovery of the Park's forests has been detrimental to both White-tailed Deer (Runge and Theberge 1974; Wilton 1987) and Beaver. Moose have, as will be seen, increased through at least the later part of this period.

Trends in Populations

Deer

The presettlement distribution of ungulates in central Canada is poorly understood, largely because bone deteriorates rapidly in the acidic soils of the Canadian Shield (Reid 1988). It is widely believed, however, that prior to European contact and the opening of the forests, deer did not range in Ontario north of approximately the location of Hwy 7, which is approximately 160 km south of the center of the Park (Matheson 1972; Smith and Borczon 1977; Smith and Verkruysse 1983). Deer bones were found in a dig of native hearths near Whitson lake in Algonquin Park but could not be reliably dated and were presumed to be post-settlement (Burns 1972*).

The earliest published evidence of deer in Algonquin Park is that of R. Bice in Wilton (1987) who reported that deer were found in the Park from at least the 1860s. There are a series of land survey records that suggest that White-tailed Deer (and Moose) were abundant in Algonquin through the late 1800s. Typically, the sur-

veyors noted that "the woods abound with moose and red deer" (Dickson 1883*; Byrne 1884*) or "red deer and moose roam all over the country" (Fitzgerald 1890*). There is, however, one dissenting voice in 1887; "little, if any, game was seen during the survey" (White Township.) (Fitzgerald 1887*).

From 1905 to 1921, G. W. Bartlett, Park Superintendent, wrote annual reports on Algonquin Park to the Minister of Lands and Forests. These reports consistently suggest that deer were very abundant. Phrases like "the deer are here simply in thousands and ... increasing" are found throughout (e.g., Bartlett 1907*). In 1911 Bartlett reported that "deer are so abundant they can be seen from the hotel veranda in numbers" and in 1910 that deer supported great hunting on the Park's boundaries and that "the Park is a great feeder for the surrounding country".

Robinson (1933) reported that deer numbered in the tens of thousands in 1921 but had declined to "possibly not more than three thousand" by 1933. Although there are no snow depth records for the time, winter temperatures were not unusually cold, indeed rather warm for the late 1920s – early 1930s (Figure 2). Robinson in fact emphasized deteriorating habitat, in part because of the suppression of fire, as the cause of the decline (Robinson 1933). The population, however, apparently recovered because C. H. D. Clarke reported a "chronic overpopulation" of deer in 1945 and reports an estimate of 13 deer/square mile, from a very early pellet group survey, a number he considered "suspiciously low" (Clarke 1945*). A. Leopold also listed the Algonquin deer population as among those "overpopulated" in North America at the time (Leopold et al. 1947).

Population estimates from pellet group surveys began to appear regularly in the 1950s. Stephenson (1958*), for example, estimated 53 deer/square mile in a wintering yard (where, of course, deer were concentrated) in Biggar Township in 1957. He was researching means to ameliorate "heavy cropping" of Yellow Birch by deer at the time (Anonymous 1957*, see research section page 72) so deer must have been abundant. Estimates from pellet group surveys for the area around Swan Lake, in the southwest corner of the Park suggested 15 deer/square mile in winter and 12 in summer in 1957 (Stephenson and Hepburn 1958*). Estimates of 12 deer per square mile would have put the Park population at approximately 36 000 animals at the time.

There was apparently significant winter mortality (a "die-off") of deer in the winters of 1958-1959 and 1959-1960 (Runge and Theberge 1974). These winters were indeed cold and snow accumulation was exceptional (Figure 2). The range was also overbrowsed at the time; Grant Taylor, retired Park naturalist, recalls that all regeneration from ground to five feet in height was browsed (G. Taylor, personal communication). The losses, however, may not have been extensive because there is an estimate of 69 deer/square mile in a yard in the Kiosk area in 1961 (Anonymous 1961*) and deer are reported to have "recovered" by 1965 (Anonymous 1965*). B. Stephenson reported 10 deer/mile^2 in summer within a 3 square mile study area located in the south of the Park in 1960 (Pimlott et al. 1969, page 29). Deer must have been common in the Park in the 1960s because the late Roy Anderson reported having "hundreds" of road-killed deer to dissect for his studies of meningeal worm, *Parelaphostrongylus tenuis*, in the 1960s (R. Anderson, University of Guelph, personal communication).

Notwithstanding this, deer apparently declined gradually through the 1960s (Rutter 1964; Runge and Theberge 1974) and this culminated in a severe die-off in the winters of 1970-1971 and 1971-1972. Wilton (1970*) estimated a population of 8090 in 1970 but that had declined to 2800 by 1972 (Wilton and Trodd 1972*). The decline was also documented in King (1976) who reported extensive mortality of deer in central Ontario in the winter of 1970-1971 and a density of only 2.02 deer/square mile in Pembroke District (which included Algonquin Park) in spring of 1972. King attributed the decline to winter severity, and snow depths were indeed exceptional (Figure. 2). Snow was also persistent those two winters; the peak of snow depth in Algonquin Park is normally the second week in March but it was mid-April in 1971 and late March in 1972.

The sharp decline of deer that occurred in Algonquin in the early 1970s happened throughout central Ontario (King 1976). Deer populations have since recovered around the Park but the Algonquin population never recovered. Deer are fairly common in the Park in summer; Park staff have been conducting road counts since 1999 and one deer is seen per approximately 270 km driven on Hwy 60 in May (roughly one deer per eight Moose, unpublished data: Algonquin Park files). However, deer are very scarce in winter. Essentially no deer or deer tracks were seen in any of the aerial deer yard surveys from 1984-2004 described earlier (including the 2002 Wolf survey). The only exception to this is the yards in the Southern "panhandle" (Figure 1) which still support deer. Deer or deer tracks are also rarely observed during winter aerial Moose surveys of the Park.

Moose

Moose were almost certainly on the early Algonquin landscape. Moose are known to have existed in Maine in the 1600s and in Quebec at the same latitude as Algonquin Park in the 1500s (Reeves and McCabe 1998). Furthermore, Peterson (1955) suggests that Algonquin Park was within the range of Moose in 1875. Intriguingly, however, it was noted in the Royal Commission Report on the founding of the Park in 1893 that Moose were unknown to the Indians prior to 1870 when they made their first appearance "at least

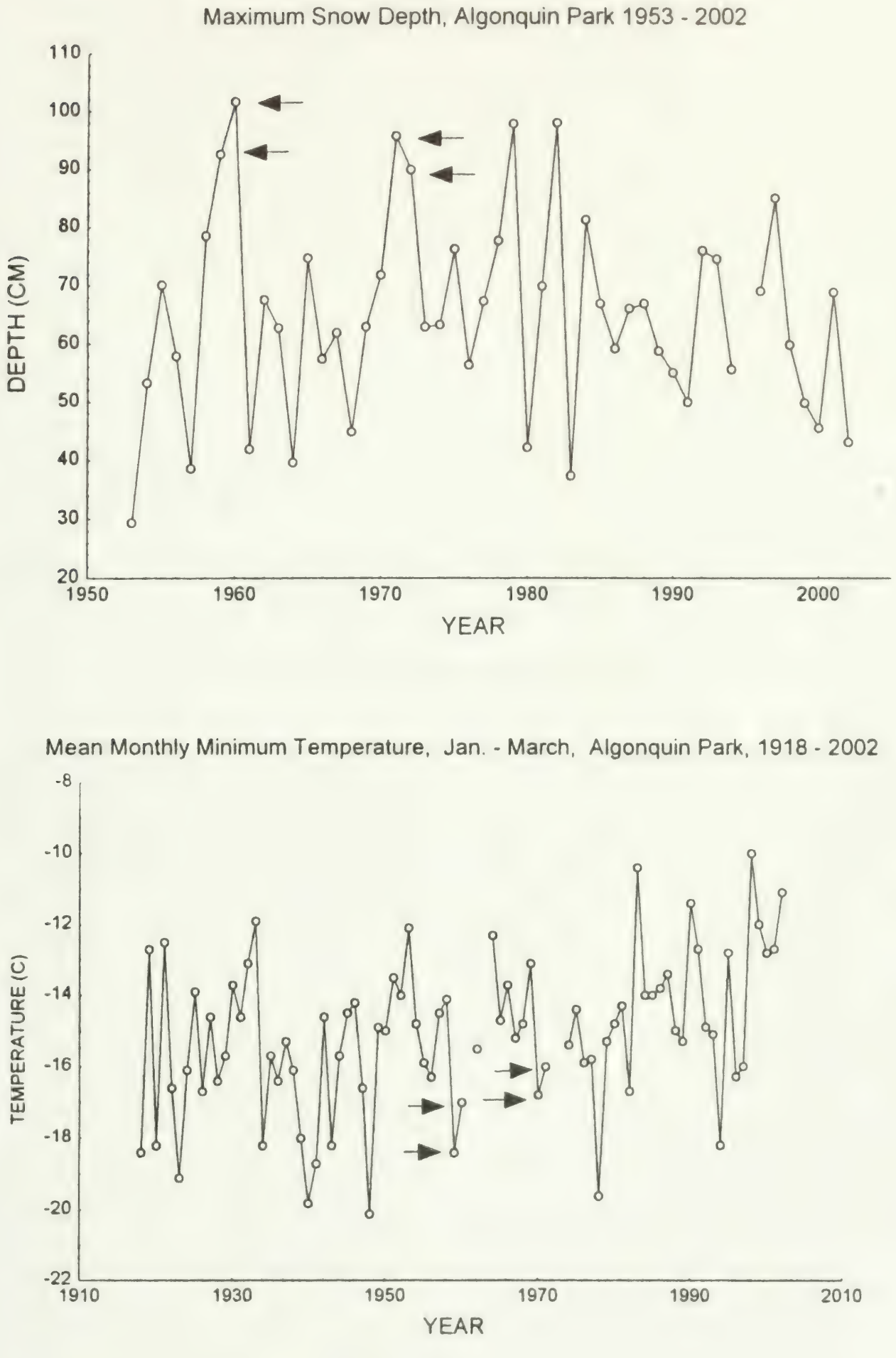

FIGURE 2. Long term trends of snow depth and winter temperature in Algonquin Park. Arrows point to years of deer die-offs.

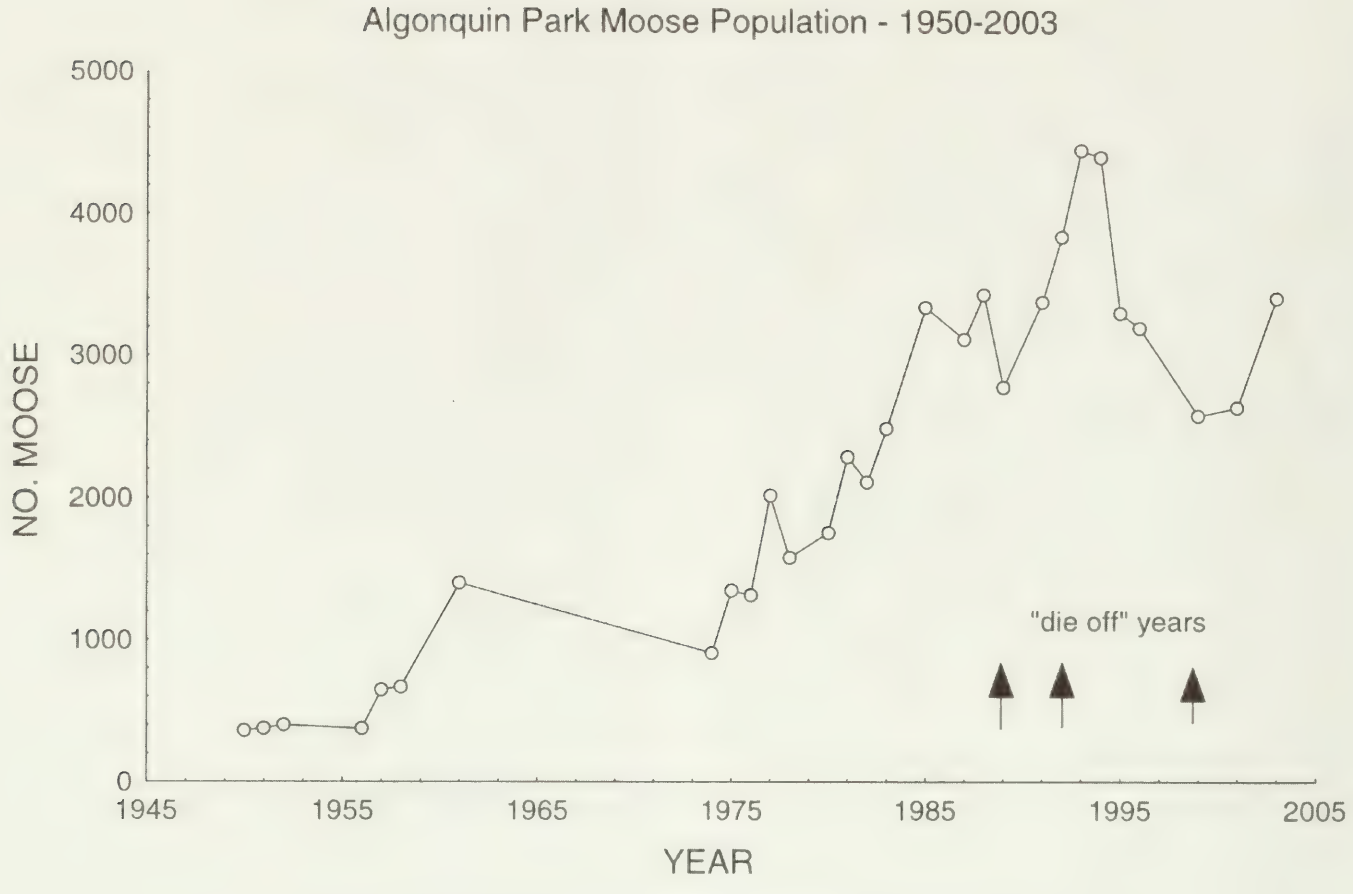

FIGURE 3. Moose population estimates, Algonquin Park, 1950 – 2003.

in recent times" after crossing over from Quebec (Anonymous 1893*).

Moose were, at any rate, well established in the Park by the late 1800s as evidenced by reports of the early land surveyors (e.g., Dickson 1883*; Byrne 1884*; Fitzgerald 1890*) discussed earlier. Reports of wasteful killing of Moose by hunters in the late 1800s in the area soon to be Algonquin Park (Anonymous 1893*) also suggest high numbers. Bartlett's annual reports, however, suggest that Moose were less common than deer in the early 1900s (Bartlett 1905-1921*). Moose are consistently referred to as "increasing" or "greatly increased" but as secondary to deer in these reports. Moose may, however, have been locally numerous as "in great numbers along the Nipissing River" in 1908 (Bartlett 1908).

There is a gap in reports of Moose abundance through the 1920s and 1930s, although Robinson (1933) reported that Moose "have increased greatly in numbers" after the "disappearance of the deer" he had noted from the early 1920s; the implication is that Moose were scarce relative to deer up to about 1921 which is in agreement with Bartlett. It seems, however, that Moose had declined again by the 1940s. Robb (1942) reports seeing only 19 Moose (but 254 deer) in Beaver surveys in the Park in 1939-1940 and C. H. D. Clarke suggested that Moose were very scarce in 1945. Clarke reported that although Moose are "distributed across the Park" only "one specimen found dead"'could be examined and that "Algonquin Park is hardly the place to study moose in Ontario" (Clarke 1945*). He further reported that only two Moose pellet groups were found in 98 deer pellet group plots.

Population estimates for Moose post-1945 are shown in Figure 3 and show a more or less steady increase until the present. Estimates in Figure 3 post-1985 are directly from the Park's data files; those prior to 85 are from DeVos (1952*); Pimlott et al. (1969, page 32); Wilton and Pashuk (1983*) (to which the 1984 and 1985 estimates were appended); and several Department of Lands and Forests annual reports from 1954-1968. The population estimates from 1956-1958 are extrapolations from estimates of Moose density for Pembroke District (which included Algonquin Park). Also, as few as 12 plots were used in some of these early surveys so they may not have been very accurate. Years missing in the inventory post-1974 are the result of poor survey conditions.

The late March survey of winter tick induced hair loss was done 14 times from 1984 to 2004. The mean H. S. I. was 1.90 (range 1.18 – 3.48) and there was evidence of heavy losses of Moose in spring following three of five surveys (March of 1989, 1992 and 1999) in which the index was > 1.95. Moose carcasses, or the stench thereof, were frequently reported by the public throughout spring of 1989 and 1992 (personal obser-

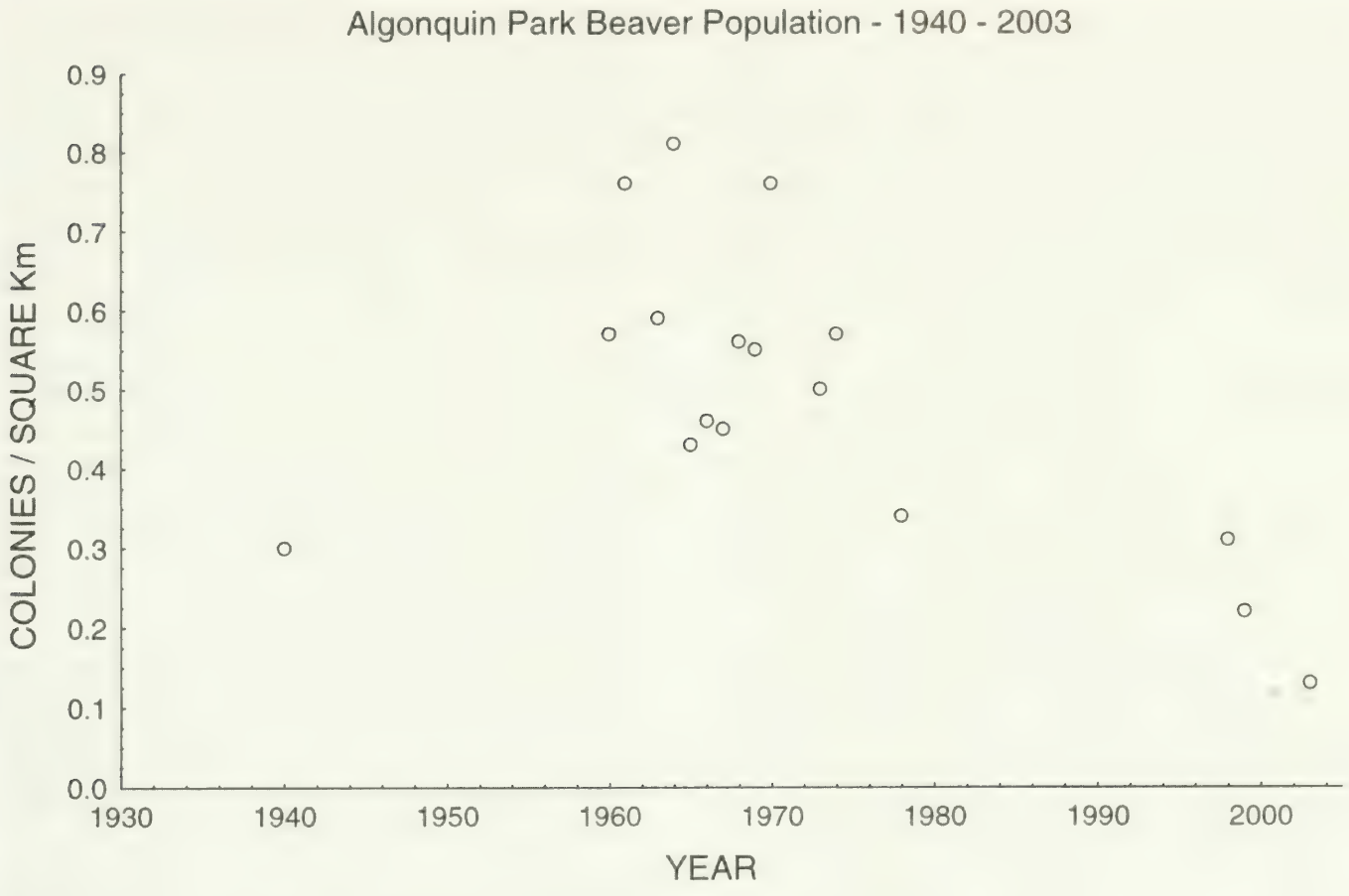

FIGURE 4. Beaver population estimates, Algonquin Park, 1940 – 2003.

vation). In 1999 (while I was on leave) the H. S. I. reached its highest and there was evidence of extensive mortalilty (B. Sandilands, Park Planner, personal communication). Unfortunately, aerial Moose surveys in two of the three winters following this apparent heavy mortality (1990 and 2000) were cancelled or only partly completed and thus the population effects are unclear [and note that the survey in winter of 1993 actually showed an increase (Figure 3)].

Beaver

There is little about Beaver from the early land surveys except a reference from 1890 about scattered Beaver meadows "now more or less dried up" (in White Township) (Fitzgerald 1890*). James Dickson Provincial Land Surveyor, however, wrote in 1888 that trapping had greatly reduced the Beaver population in the region soon to become Algonquin Park and Peter Thompson, first Park Superintendent, reported that "scarcely a beaver could be seen" (Hall 1971). By 1899, however, the Beaver population had reportedly recover-ed and were so numerous by 1909 that the Park Superintendent recommended that trapping (which had been suspended) be reinstated (Hall 1971). Superintendent Bartlett's reports suggest that Beaver flourished from 1905-1921. In 1906, for example, Bartlett wrote that "fur bearing animals have greatly increased, especially the beaver". Bartlett reported in 1908 that "the beaver can be found in numbers upon every lake, river, pond and creek" and in 1909, "in large healthy colonies wherever there is a drainage ditch" (he lamented the extent of "nuisance" problems Beaver were causing in the 1908 report). The remaining reports frequently note Beaver increasing, for example "the annual increase of which (Beaver) runs into the thousands" in 1919.

Information is lacking for the Park for the 1920s. However, Beaver were apparently plentiful across the province up until 1923 but declined sharply (province-wide) in 1924 and remained low, and of concern, until 1930 (Anonymous 1923-1930*). No reason is given for the decline and it is not clear if the decline occurred also in Algonquin Park.

Robb (1942) reported a density of 0.29 Beaver colonies/km^2 in 1940 in the south-center of the Park but Hall (1971) believed that Robb underestimated the population and reported that Beaver populations had fluctuated between 0.40 – 0.80 colonies/km^2 from 1955 to 1971. Beaver must have been relatively abundant in the 1950s because R. Stanfield reported an "unusually high density" in 1955 and between 58 and 77 colonies/100 "bodies of water" in 1957 and that this was high "relative to all other Districts except North Bay" (Stanfield 1957*).

Population density estimates of Beaver (colonies/km^2) for the Park from 1940 to 2003 are shown in

Figure. 4. These data are primarily Stanfield's survey [summarized in Smith (1969*)] and its recent continuation (Addison 1998*), but include several other independent estimates (Robb 1942; Wilton 1974*; Regan 1978*). The data suggest that the Beaver population has declined sharply since the late 1970s (Figure 4). This is reflected in independent studies in the south-center of the Park by J. Fryxell, who reported a significant 50% decline of Beaver from 1987-1998 (Fryxell 2001).

Discussion

In summary, White-tailed Deer appear to have been common in Algonquin Park in the late 1800s while Moose were present but secondary to deer. Deer remained abundant and apparently increased through the early 1900s until a decline from the early 1920s to the early 1930s. Deer had recovered by the early 1940s and were common through the 1950s but began to decline in the 1960s and suffered severe losses due to winter severity in the early 1970s and have not recovered. Moose were apparently secondary to deer in the early 1900s and probably relatively scarce until the decline of deer in the 1920s when they are reported to have increased. By the 1940s, however, Moose had declined (coincident, apparently, with the recovery of deer) and appear to have been quite rare by the mid-1940s. Aerial surveys show an increase in the Moose population beginning in the mid-1950s that accelerated with the decline of deer in the early seventies. Moose are now the dominant ungulate in what was a Wolf-deer system through most of the last century. Beaver were scarce until the formation of the Park in 1893 whereupon they increased rapidly and were very common through the early 1900s. There are little data on Beaver until aerial surveys first began in 1940. Surveys and qualitative assessments suggest that Beaver were abundant and more or less stable at about 0.5 colonies / km^2 through mid-century but began to decline in the mid-1970s and are now at less than half of their peak abundance.

The conventional explanation for the observed trends in White-tailed Deer and Moose is that the removal of coniferous cover and gradual maturation of the forest have been detrimental to deer and, consequently, of benefit to Moose (Robinson 1933; Runge and Theberge 1974; Wilton 1987). Presumably, maturation of the forest also accounts for the decline of Beaver (Addison 1998*). The system, however, is more complex than just that and a more detailed discussion is in order.

The opposition of Moose and deer numbers over time is intriguing given the potential virulence of meningeal worm to Moose (Anderson 1964). Meningeal worm is widely distributed in eastern North America and present in Algonquin Park and one is tempted to conclude that Moose increased in the Park as deer, and the rate of transmission of *P. tenuis*, declined. Wildlife managers in the Park and elsewhere have assumed this effect occurs, at least with relatively high deer densities (e.g, Karns 1967). However, the ecological role of meningeal worm is poorly understood and evidence for the degree of its impact on Moose has been challenged (Nudds 1990). Nevertheless, the parasite must remain implicated as having a potential role in the recurring divergence of Moose and deer numbers in the Park.

There are other enigmatic questions regarding Moose and White-tailed Deer. For example, the scarcity of deer in the Park in winter while deer are abundant all around the Park is hard to explain. It is, as discussed, widely believed that this is a result of the deterioration of habitat in the Park but also because winter weather is more severe than for the surrounding landscape. The latter is true; for example mean monthly minimum temperatures in winter are lower in a zone centered on the core of the Park than the surrounding area (Anonymous 1984). Yet deer winter in large numbers in yards almost adjacent to the Park boundary where winter weather is only marginally different. For example, deer winter in the hundreds in yards near Dorset (J. MacDonald, O. M. N. R., Bracebridge, personal communication) only 15 km from the Park boundary and at 1100 m elevation vs 1250 m for Hogan Lake, one of the original yards in the Parks's core. The structure and composition of the forest around Dorset and the surrounding landscape, is, superficially at least, similar to that of the Park (personal observation). Why, then, are deer so scarce in the Park in winter?

Wolves may be the answer to this question. We occasionally find Wolf-killed deer in the Park in mid-winter in places where their presence was not previously obvious. In the 2002 aerial Wolf survey one of only four deer observed was a recent Wolf kill and a second was being pursued by Wolves. It seems that Wolves are very effective at finding the few deer that do winter in the Park (Forbes and Theberge 1996). Possibly, White-tailed Deer have not been able to reoccupy the Park after the die-offs of 1971 and 1972 because Wolves have essentially excluded them (at least in winter). There is in fact a body of evidence that predation is disproportionately heavy on isolated groups of deer wintering away from the core of large yards (Kolenosky 1972; Nelson and Mech 1981; Patterson and Messier 2000).

Another aspect of this question is the effect on deer of supplemental feeding around the Park in winter. Deer on the Park's east side are known to migrate out of the Park in winter to areas to the southeast where supplementary feeding is widespread (Forbes and Theberge 1995). Supplementary feeding occurs around much of the Park and has for decades, but became commonplace after the decline of 1970-1972 (M. Wilton, O. M. N. R, retired, personal communication) (it is not practised in the Park). Deer exhibit strong philopatry and will bypass good quality habitat to

winter in hereditary yards even where quality of habitat is poor (Voigt et al. 1997). Possibly, supplementary feeding has, over time, created a fixed "culture" of seasonal movement out of the Park. Lewis and Rongstad (1998) showed that supplementary feeding of deer can influ-ence migration.

One hypothesis, then, to explain the recent history of deer in Algonquin Park is as follows: The decline of deer in central Ontario in the early 1970s was particularly severe in Algonquin Park. Deer recovered around the Park but were slower to do so in Algonquin because of poorer quality of habitat and somewhat more difficult winters. Supplementary feeding, which began in earnest shortly after the decline of deer, presented a draw that developed into fixed winter migrations and the few deer that try to break that mode are killed by Wolves.

Moose also present a dilemma. With the exception of some island populations in northwestern Ontario, Algonquin Park has supported the highest Moose population density in the Province for years; typically showing densities three times higher than in northern management units (O. M. N. R., Wildlife Surveys and Records). The Park, however, is almost the antithesis of good Moose habitat. Quality Moose habitat is traditionally viewed as landscapes that are extensively disturbed; boreal forests with a mix of burns and/or clearcuts amidst winter cover and aquatic feeding areas (e.g., Peek 1998). Algonquin Park, or at least its western two thirds where Moose densities are highest, is a closed-canopy tolerant hardwood forest with very few openings larger than a few hundred square meters (Anonymous 2000*; Quinn 2004). Fire has not been active on the Alqonquin landscape for decades and, even when not suppressed, is very rarely a stand destructive event in tolerant hardwoods (Lorimer and Frelich 1994). Partial cutting systems in hardwoods can provide substantive browse (Kelty and Nyland 1983) but much less than clearcuts (Monthey 1984). Why, then, are there so many Moose in the Park?

Here, again, the answer may lie in predation for, on the Park's west side at least, there is no effective predator acting on Moose. Hunting by a local aboriginal community is permitted on the east side of the Park in a zone corresponding roughly to the extent of pine forest (about 40% of the Park's area). The west side (hardwood) area is, however, unhunted. Further, Algonquin's Wolves, although capable of killing Moose, are principally a "deer-eating" type (Pimlott et al. 1969), and primarily a scavenger of Moose in winter (Forbes and Theberge 1992, 1996). A hypothesis regarding the Algonquin Moose population thus goes as follows: Moose are at high densities in Algonquin Park because of the lack of an effective predator, not the quality of habitat. Habitat is marginal but acceptable; selective cutting provides a limited but continuous supply of browse and coniferous cover, while generally unsuitable for deer, is adequate for Moose. Relatively low predation pressure, and very low densities of deer (and thus *P. tenuis*) allow Moose to do well in a forest environment that is not optimal.

A less well understood player in this system is the Black Bear (*Ursus americanus*). Black Bears prey on Moose calves and can limit Moose populations (Stewart et al. 1985). Data on bear predation on Moose calves in Algonquin, however, are sparse. Moose are believed to calve preferentially on islands and peninsulas in the Park to avoid bears (Addison et al. 1990) but Garner (1994) showed a predation rate of bears on Moose calves in the Park of only 8% which is low relative to that suggested by removal studies of Brown Bears (*Ursus arctos*) in Alaska (Miller and Ballard 1992) and Black Bears in Saskatchewan (Stewart et al. 1985).

The Algonquin ecosystem, and particularly the complex interplay of Wolf-prey, habitat, weather, and parasites will continue to evolve and present challenges to Park managers. The future of the Park's Wolves will depend largely on trends of these prey populations. This basic truism has largely been overlooked in the discussion on the status of Algonquin's Wolves which has focused on human killing around the Park as the cause of the possible decline (Theberge 1998). This paper suggests that declining prey may be at least as important a factor. Algonquin's Wolves are small and prey preferentially on deer (Pimlott et al. 1969; Forbes and Theberge 1996). The near absence of deer in winter and decline of Beaver, an important summer food, must be stressful to the population, as has been documented in Minnesota (Van Ballenberghe and Mech 1975). The increase of Moose has in part compensated but Algonquin's wolves are primarily scavengers of Moose in winter (Forbes and Theberge 1996) and may find food energy from Moose readily available only in winters of tick induced mortality.

Algonquin Park, and its wolves and prey, do not exist in isolation. Indeed, recent work suggests that Algonquin's wolves are not unique but genetically identical to and freely interbreeding with wolves around the Park (Grewal 2001). The larger population, a distinct taxon, the "Eastern Canadian Wolf", *Canis lycaon,* (Wilson et al. 2000) extends from Manitoba to Quebec and numbers approximately 10 000 (Van Zyll de Jong 1996*; White et al. 2001*). External phenomena that are both minor and local, like feeding deer, and great and global, like climate change, will perhaps have as much influence on future trends in the distribution and abundance of *C. lycaon* as changes within the Park itself.

Acknowledgments

A great many biologists and other Park staff, far too numerous to mention, contributed to the collection of the data that have been presented. Particular recognition should, however, be given to those that have worked in the Park in the more recent past and in particular, M. Wilton, E. Addison, R. Anderson, D. Voigt, G. Forbes, J. Theberge, B. Stephenson, and R. Stanfield. E. Hovinga has directed Moose surveys in the Park in

recent years and is one of a long list of Moose flyers with strong stomachs and large bladders. V. Michalsen assisted with the figures. B. Patterson provided useful comments on an early draft.

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Received 29 May 2003
Accepted 15 November 2004

The Distribution and Habitat Selection of Introduced Eastern Grey Squirrels, *Sciurus carolinensis*, in British Columbia

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Gonzales, Emily K. 2005. The distribution and habitat selection of introduced Eastern Grey Squirrels, *Sciurus carolinensis*, in British Columbia. Canadian Field-Naturalist 119(3): 343-350.

Eastern Grey Squirrels were first introduced to Vancouver in the Lower Mainland of British Columbia in 1909. A separate introduction to Metchosin in the Victoria region occurred in 1966. I surveyed the distribution and habitat selection of Eastern Grey Squirrels in both locales. Eastern Grey Squirrels spread throughout both regions over a period of 30 years and were found predominantly in residential land types. Some natural features and habitats, such as mountains, large bodies of water, and coniferous forests, have acted as barriers to expansion for Eastern Grey Squirrels. Given that urbanization is replacing conifer forests throughout southern British Columbia, it is predicted that Eastern Grey Squirrels will continue to spread as habitat barriers are removed.

Key Words: Eastern Grey Squirrels, *Sciurus carolinensis*, distribution, habitat selection, invasive, British Columbia.

The vast majority of introduced species do not successfully establish populations in novel environments (Williamson 1996). Many successful non-native species are human comensals which thrive in human-modified environments (Williamson and Fitter 1996; Sax and Brown 2000). Eastern Grey Squirrels (*Sciurus carolinensis*; hereafter EGS), a charismatic species endemic to eastern and central North America, have been intentionally introduced to Great Britain, Italy, Ireland, South Africa, Australia, and western North America (Robinson and McTaggart-Cowan 1954; Seebeck 1984; Gurnell 1987; Lever 1994). Their gregarious nature has made them a popular addition to city parks and they generally flourish in this land type whether they are native or introduced. The ability of EGS to establish populations in association with humans is likely a key to their success as an invader. This study aims to update what is known about the spread and distribution of introduced EGS in southwestern British Columbia. I also analysed their habitat usage and predicted that EGS would be found predominantly in residential areas, areas that more closely resemble their native environment.

EGS occur naturally in the eastern United States and central Canada. Their distribution coincides with eastern hardwood forests; especially nut producing trees such as oaks (*Quercus* spp.), hickories (*Carya* spp.), and, formerly, American Chestnut (*Castanea dentata*). Their coats are often grey or black and, more rarely, red, blonde, and white. EGS eat nuts, fruits, fungus, and, opportunistically, eggs and nestlings (Orr 1971). EGS are most successful in deciduous forests, mixed deciduous-conifer forests, and residential areas (Barkalow and Shorten 1973; Pasitschniak-Arts and Bendell 1990; Riege 1991). The highest densities of EGS in the wild occur in mature maple-oak forests and the lowest in fir-cedar forests (Riege 1991). Very high densities of EGS have been observed in residential areas such as backyards, parks, and cemeteries (Pasitschniak-Arts and Bendell 1990). EGS co-occur with North American Red Squirrels (*Tamiasciurus hudsonicus*) throughout much of their range where habitat specialization and not competition determines the differences in their distributions (Riege 1991).

EGS have had negative economic and ecological effects in the places where they have been introduced. In Europe, EGS strip the bark from trees, damaging both native and plantation species (Kenward and Parish 1986). EGS may also replace European Red Squirrels (*Sciurus vulgaris*) in Great Britain (e.g., Lloyd 1983; Wauters and Gurnell 1999; Gurnell et al. 2004), although studies demonstrating the mechanism of replacement have been inconclusive. Attempts to eradicate, control, or slow the spread of EGS have been costly failures, in part due to a lack of understanding of the population biology and methods of spread of EGS (Sheail 1999; Gonzales 2000*; Bertolino and Genovesi 2001). Conifer forests and plantations, mountainous terrain, and bodies of water have slowed spread or were barriers to movement, while deciduous forests and poplar plantations have provided suitable habitat for EGS in Europe (Williamson and Brown 1986; Wauters et al. 1997; Ó Teangana et al. 2000a, 2000b). EGS were found in conifer forests in Great Britain, but the maintenance of those populations required immigration from neighbouring habitat types (Kenward and Hodder 1998; Bryce et al. 2002). The role of conifer forests in limiting the spread and establishment of EGS has led to broad scale land management recommendations that involve the maintenance of conifer forests/plantations and the removal of large seed deciduous trees, particularly oaks (Kenward and Hodder 1998; Bryce et al. 2002).

Conifer forests historically dominated British Columbia and habitat conversion from conifer forest to

residential development with deciduous trees may have increased the amount of suitable habitat for EGS. Today, residential areas in the Victoria region and Lower Mainland are well treed with deciduous species. Gardens, bird feeders, garbage and hand-outs provide an abundance of food while trees and human dwellings provide nesting locations.

The first introduction of EGS to British Columbia occurred in 1909 when at least six individuals from the New York Park Department were brought to the peninsula of Stanley Park in Vancouver (Steele 1993). The population increased and had achieved a stable size by the 1920s (Robinson and McTaggart-Cowan 1954). Robinson and McTaggart-Cowan (1954) surveyed the population and natural history characteristics of EGS in Stanley Park in 1950. EGS were found predominantly in deciduous forests, mixed deciduous-conifer forests, and developed areas rather than in the conifer forests that dominate Stanley Park. Their diet was primarily composed of hand-outs from visitors, nuts from horticultural trees, and samaras from native maple trees. Although EGS are known to eat eggs and nestlings, these authors did not find any occurrences of this. The authors speculated that EGS would remain confined to Stanley Park because it was effectively an island, surrounded by the Burrard Inlet and downtown Vancouver. EGS remained on the peninsula until the mid-1970s, when populations began spreading to adjacent areas (Merilees 1986, 1992; Gonzales 1999).

EGS were first introduced to Vancouver Island in 1945 (Ringuette 2004). A small population was introduced to Beacon Hill Park in the city of Victoria. They disappeared, however, and the current population of EGS are believed to be descendants of an introduction that occurred in the autumn of 1966. Three individuals were acquired from southwestern Ontario for a private game farm in Metchosin, within the Greater Victoria area (Guiguet 1975; Fraser 1987). These EGS were released some years after their arrival and had spread to neighbouring municipalities by 1975 (Guiguet 1975).

Study Areas

Both study sites are in southwestern British Columbia, Canada, and are separated from each other by a 40 km ocean strait (Figure 1). Both sites have mild climates and mean annual temperatures of 8°C-10°C. The Lower Mainland, an area of approximately 1500 km^2, is located in the moist Coastal Western Hemlock biogeoclimatic zone (Pojar et al. 1991). Prior to development, this region was predominantly conifer forest. Natural areas are still dominated by conifers, particularly Western Hemlock (*Tsuga heterophylla*), Western Red Cedar (*Thuja plicata*), and coastal Douglas-fir (*Pseudotsuga menziesii*). Residential areas have numerous horticultural trees, both in private gardens and along boulevards. For example, the Vancouver Park Board maintains over 124 000 trees comprising over 600 species and cultivars, the majority of which are deciduous (Vancouver Board of Parks and Recreation 2005*).

The Victoria region is an area of approximately 460 km^2 located in the Coastal Douglas-fir biogeoclimatic zone (Nuszdorfer et al. 1991) on the southeastern tip of Vancouver Island. Natural areas are dominated by coastal Douglas-fir, Shore Pine (*Pinus contorta*), and Western Red Cedar. Residential areas have a large variety of horticultural trees. The most common boulevard trees are Japanese flowering cherries (*Prunus* spp.) and Horse Chestnuts (*Aesculus hippocastanum*). Garry Oaks (*Quercus garryana*) are endemic to the region and the acorns may provide a food source for EGS.

Given the negative effects of EGS in Europe, there is speculation that EGS have negative ecological impacts in British Columbia. EGS may eat and damage a sufficient number of Garry Oak acorns to impede their regeneration (Bruemmer et al. 2000*). EGS may also compete for resources with endemic squirrels (Garry Oak Ecosystem Recovery Team 2003). North American Red Squirrels are endemic to the Victoria region and Douglas Squirrels (*Tamiasciurus douglasii*) and Northern Flying Squirrels (*Glaucomys sabrinicus*) are endemic to the Lower Mainland.

Methods

I conducted field surveys and solicited sightings of squirrels from the public, particularly naturalists, from 1996 to 2000, through paper and telephone surveys and a web page. A series of questions determined the presence or absence, location, coat colour and the year that EGS were first sighted at a location. A lack of squirrel sightings from the public surveys could be due to an absence of squirrels or a sampling effect. To ensure representative sampling across all land types, I conducted surveys in areas that were underrepresented by the public surveys. Using Geographic Information Systems (GIS), I overlaid a grid comprised of 5 km × 5 km cells onto each study area. Cells without sightings of squirrels were identified by land type on

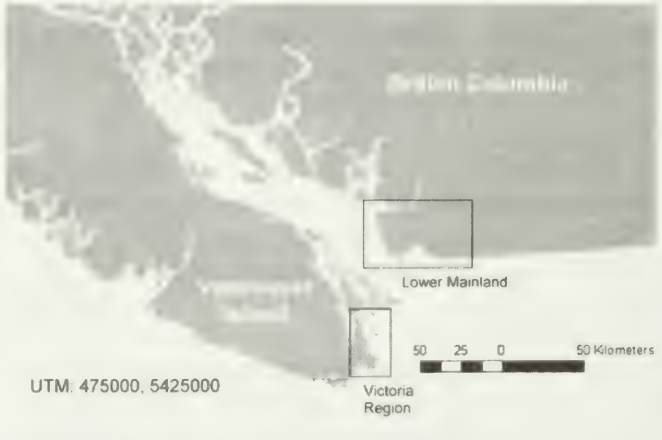

FIGURE 1: Map of southwestern British Columbia showing the Lower Mainland and the Victoria region.

a digital landscape map and the total area of each land type was computed. I calculated the number of public responses by land type to get a measure of "survey effort" by land type. Surveys were conducted in each of the land types so that each land type had an equal level of survey effort proportional to its presence on the landscape. Trained volunteers and I conducted 175 hours of auditory and visual searches for EGS, Douglas and Red squirrels. Surveys occurred from 8 am to 11 am, when squirrels are generally more active. Surveyors stayed at a point location for 10 minutes before moving to the next location approximately 100 m away. In addition to watching for EGS, Douglas, or Red squirrels, surveyors also listened for their calls to confirm their presence.

I also acquired submission records for EGS, Douglas and Northern Flying squirrels from three wildlife shelters located in different municipalities in the Lower Mainland for the years 1983 to 2003. Submission records begin in 1983, before EGS had spread to most municipalities in the Lower Mainland. The shelter records were used to augment the public surveys to plot the spread of EGS by year across the Lower Mainland. The records did not state the specific location where the squirrels were found, and therefore were not used in the habitat selection analysis.

I tested whether EGS use the land types proportional to their availability using a log-likelihood chi-square test with 95% confidence limits and a Bonferroni correction (Neu et al. 1974; Manly et al. 1993). The locations of EGS, given by nearest street intersection, landmark or GPS coordinates, were converted into UTM coordinates and overlaid onto digital maps using ArcView 3.2 (Environmental Systems Research Institute 1998*). Six land type categories, each ground-truthed with field surveys, were categorized on maps and included: (a) *Agriculture* (farmland and treeless fields); (b) *Parks* (municipal, regional, and provincial parks); (c) *Schools* (including fields, treed and undeveloped areas around a building or buildings; (d) *Industrial* (city centres and heavily developed areas); (e) *Residential* (urban and suburban areas); and (f) *Open* (cleared areas). Department of National Defence lands in the Victoria region (fields with some development) were included in the *Open* category. Land types in which squirrels were never sighted, such as lakes and gravel pits, were excluded from the analysis.

Results

In total, 212 responses were received for the Lower Mainland and 383 for the Victoria region. Wildlife shelter records provided an additional 4937 municipal locations of squirrels for the Lower Mainland. Over the 20 years, there were a total of 264 Northern Flying Squirrels, 656 Douglas Squirrels, and 4017 EGS brought to the wildlife shelters (Figure 2). EGS first arrived at the shelters in 1985 and their numbers have increased exponentially until 2000. EGS did not move contiguously through the municipalities in the two study sites. While it is likely that there were gaps in

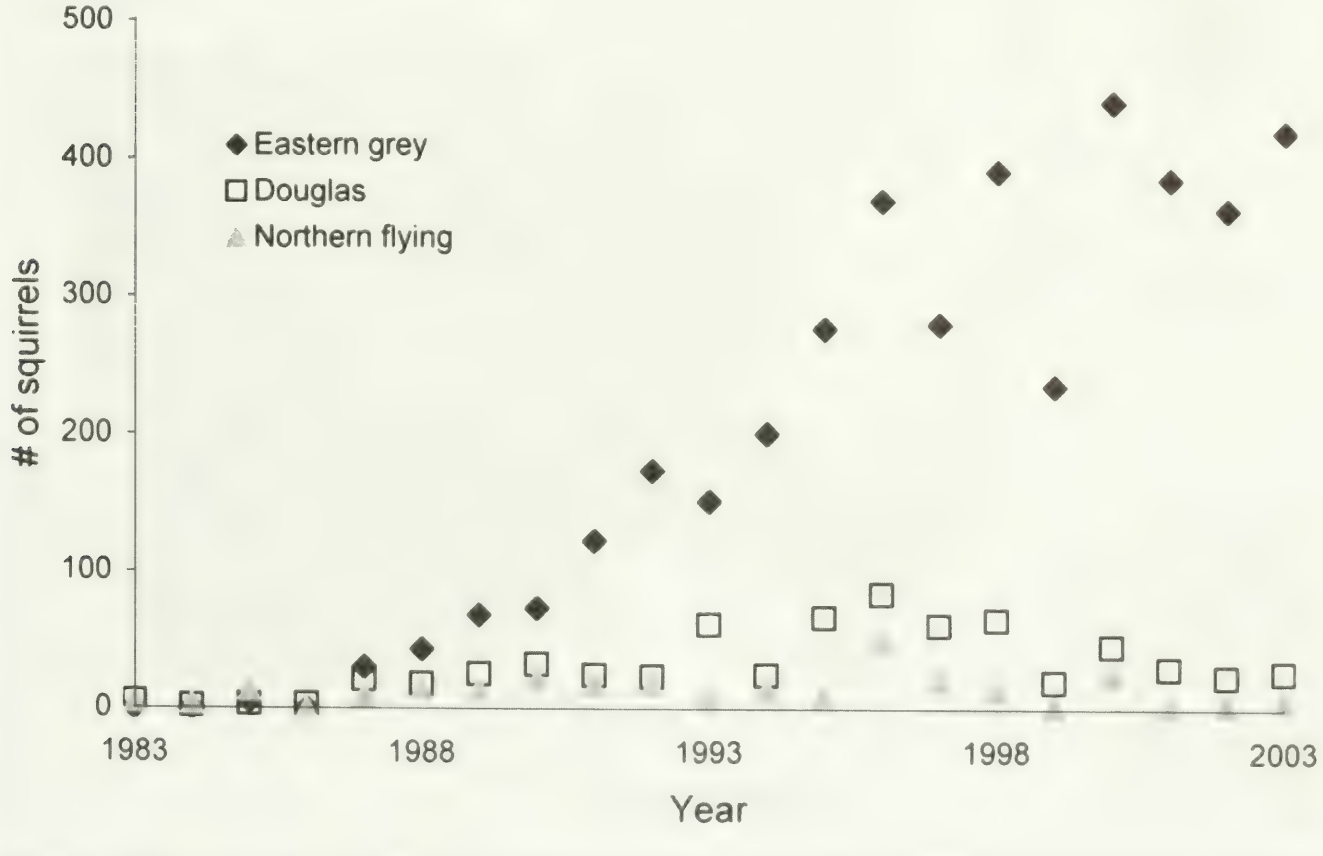

FIGURE 2. Number of Eastern Grey, Douglas and Northern Flying squirrels from wildlife shelters in the Lower Mainland from 1983 to 2003.

the temporal data, the translocation of EGS by humans also explains the discontiguous pattern of expansion. The surveys revealed that residents and pest control companies translocated live EGS, often beyond a "barrier" such as a river or mountain in the hopes that nuisance EGS would not return (Pynn 1999*). By 2004, EGS occurred throughout the Lower Mainland (Figure 3) and the Victoria region (Figure 4).

The habitat selection analysis revealed that EGS did not use the land types in proportion to their prevalence ($\chi^2 << 0.001$, df = 5). EGS were found predominantly in the land type when the proportion of EGS is significantly above the proportion of the land type's availability (Figures 5 and 6). EGS in the Lower Mainland were found predominantly in *Residential* land types and not in *Agricultural* or *Open* land types (Figure 5). EGS in the Victoria region were also found predominately in *Residential* land types and not in *Agricultural*, *Open*, or *Parks* land types (Figure 6).

Discussion

EGS have spread predominantly toward *Residential* areas. In the Lower Mainland, the Pacific Ocean to the west and conifer forest and mountains to the north have acted as barriers to their spread. Suitable habitat, specifically residential development, is available south and east and spread has proceeded further and more quickly in these directions. A similar pattern was seen in the Victoria region where EGS spread throughout the eastern peninsula of Vancouver Island, toward residential areas rather than west and north into areas dominated by conifer forests. The results suggest that EGS may continue to invade British Columbia, but are more likely to do so in residential areas and are unlikely to spread in areas still dominated by conifer forests. The land type categories were very general, however, because of the size of the region. I used the most detailed landscape data available for the breadth of the study areas. Localized studies that defined spe-

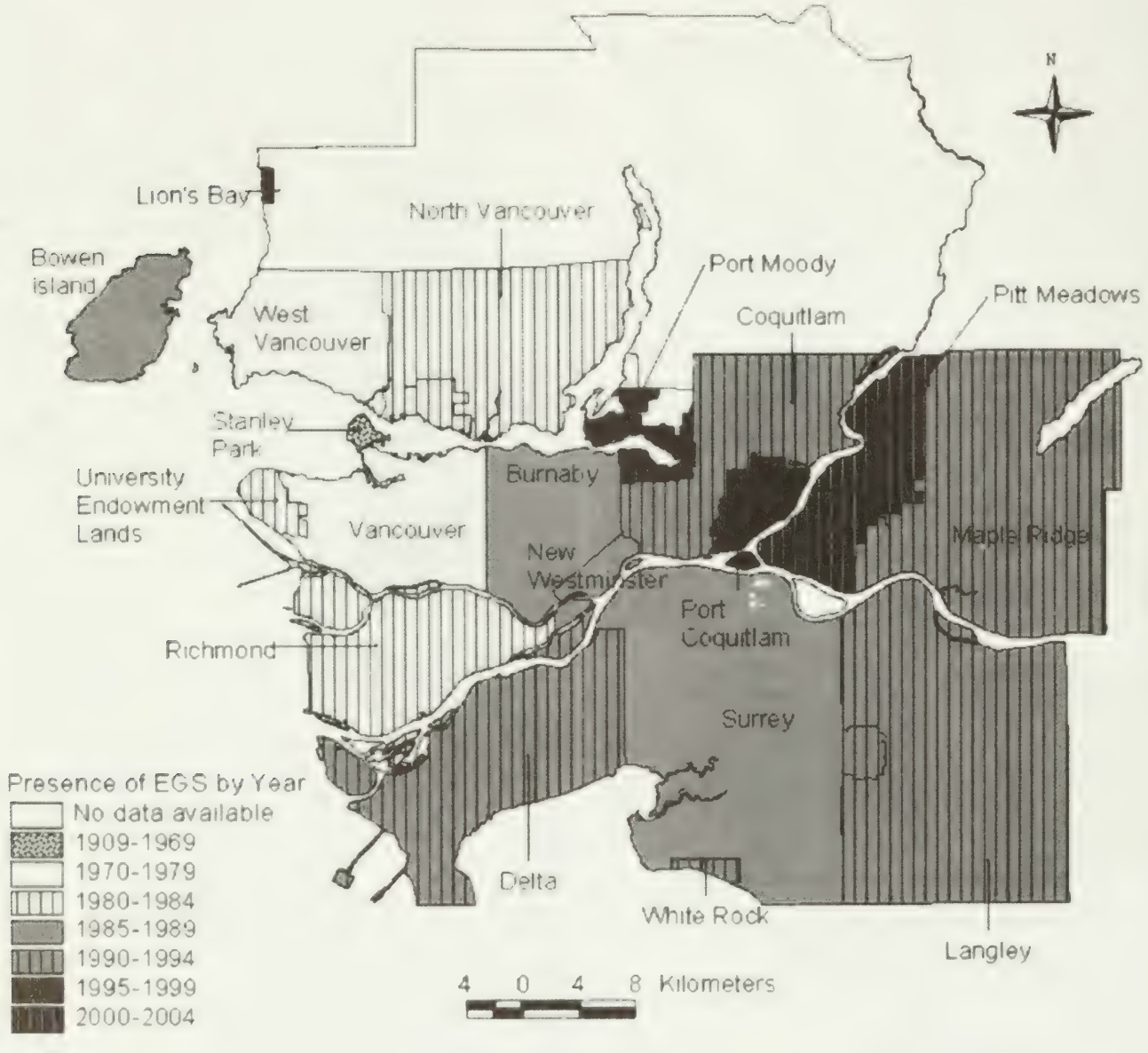

FIGURE 3. The spread of Eastern Grey Squirrels in the Lower Mainland from 1909 to 2004.

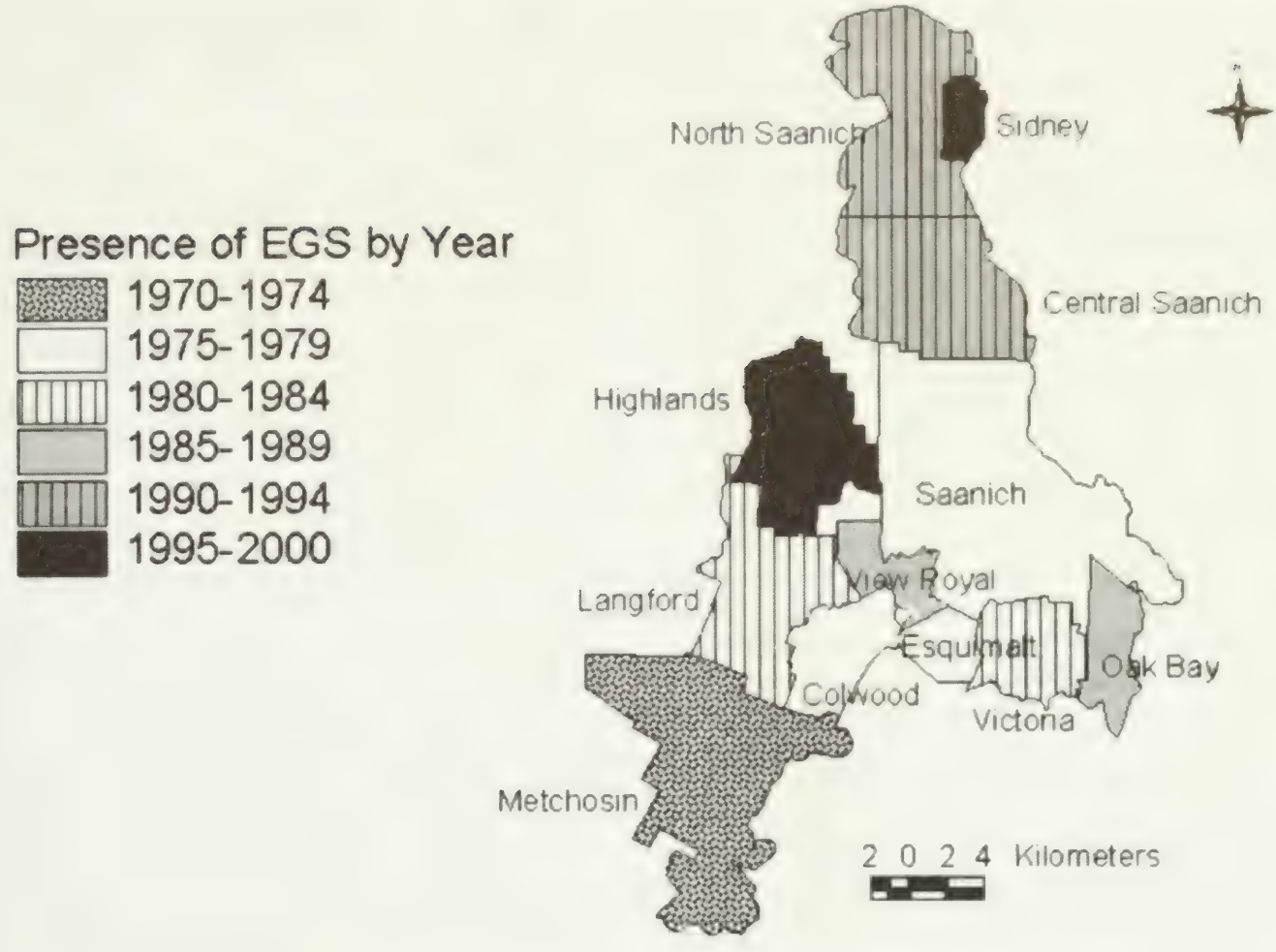

FIGURE 4. The spread of Eastern Grey Squirrels in the Victoria Region from 1970 to 2000.

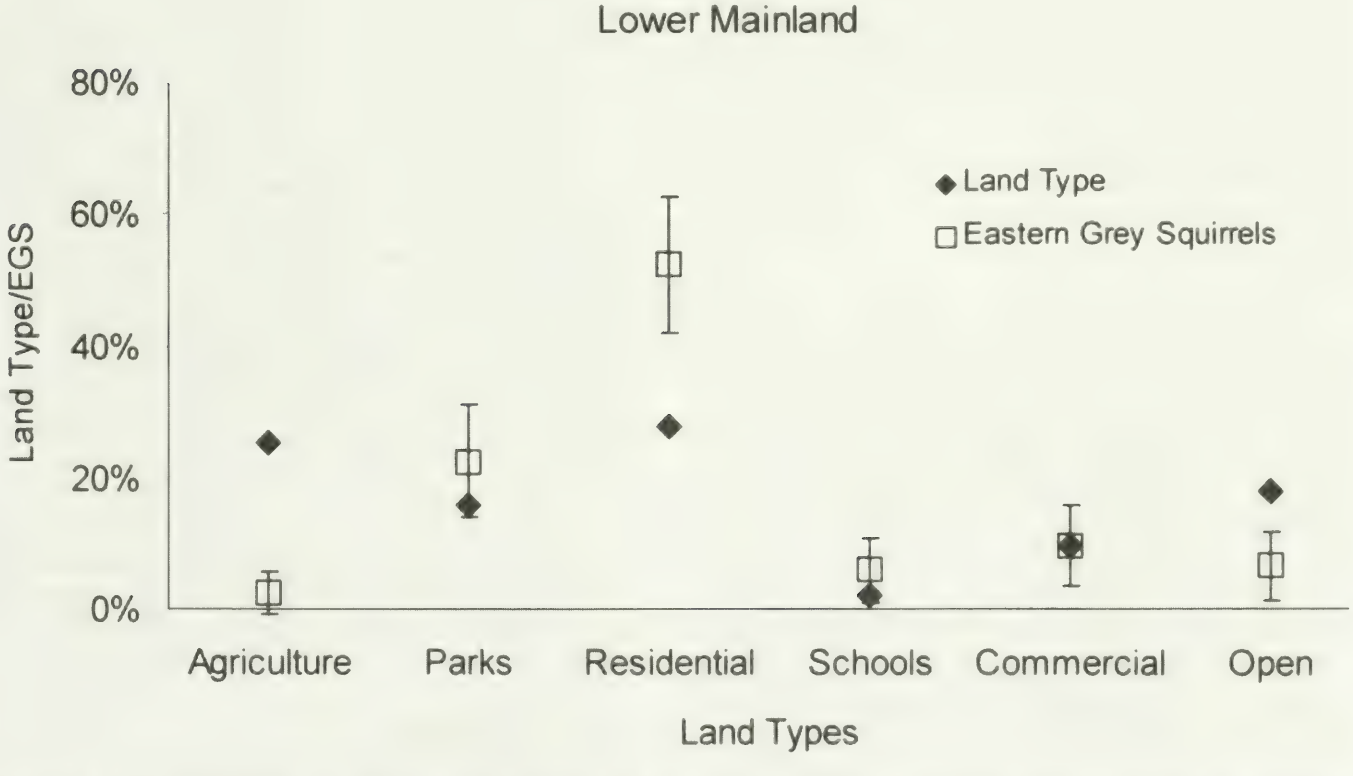

FIGURE 5. Habitat selection of Eastern Grey Squirrels in the Lower Mainland. The proportion of Eastern Grey Squirrels found in each land type with 95% confidence intervals ($\chi^2 << 0.001$, d.f. = 5). Eastern Grey Squirrels were found predominantly in *Residential* land types and not in *Agricultural* or *Open* land types.

cies of trees, the locations of bird feeders and other resources, would further our understanding of the specific habitat needs of EGS at fine scales.

While some introduced species can have profoundly negative effects on native species, the majority are benign (Williamson 1996). Further, landscape conversion that favours many successful invaders is simultaneously detrimental to native species. The result may appear to be the displacement of native species by non-native species, but this interpretation is confounded by the changes in the landscape. The squirrels endemic to the Lower Mainland evolved in a landscape dominated by conifer trees. If there has been a decline in endemic squirrels, it is more likely that the decline is related to habitat loss than to direct competition with EGS. If EGS competitively displaced native squirrels in the Lower Mainland, we would expect to see the extirpation of Northern Flying Squirrels and Douglas Squirrels where EGS were first introduced. All three species of squirrels have been present at the original site of the introduction, Stanley Park, for nearly 100 years (personal communication, Michael Macintosh, Supervisor at the Vancouver Board of Parks and Recreation).

Although EGS and North American Red Squirrels co-occur throughout most of their native range through habitat segregation (Riege 1991), North American Red Squirrels are thought to be declining due to EGS in the Victoria region (Bruemmer et al. 2000*; Garry Oak Ecosystem Recovery Team 2003). The decline of Red Squirrels, however, may be coincident with or exacerbated by habitat loss. For example, a survey respondent reported that North American Red Squirrels disappeared from southeastern municipalities in the Victoria region in the 1940s as residential development increased. The replacement of natural areas with residential development allows EGS to fill an "empty niche" rather than actively displace native squirrels. EGS may negatively impact native squirrels on local scales where their habitats overlap such as mixed deciduous-conifer forests or rural residential areas, but at a regional scale, EGS are likely to co-occur as long as there is sufficient suitable habitat for each of them.

There is some concern that EGS reduce the regeneration of Garry Oaks, an important species in endangered Garry Oak ecosystems, by eating acorns, notching acorns, and stripping the bark from young trees (Bruemmer et al. 2000*; Garry Oak Ecosystem Recovery Team 2003). This belief, however, is contradictory to the literature that supports a net benefit for tree regeneration from scatter hoarding squirrels (e.g., Vander Wall 2001; Goheen and Swihart 2003). For example, North American Red Squirrels have recently expanded their range in Indiana, areas previously dominated by EGS. EGS are concurrently declining due to land conversion, an interesting contrast to EGS in British Columbia. Goheen and Swihart (2003) predict that the replacement of scatter hoarding EGS with larder hoarding Red Squirrels will result in the decline of Black Walnut (*Juglans nigra*), Red Oak (*Quercus rubra*), and Bur Oak (*Quercus macrocarpa*) regeneration.

Conclusions

A disproportionate number of successful introductions of non-native species occur in disturbed habitats (Williamson 1996). As humans convert natural areas into residential areas, they facilitate the spread of non-native, human comensal species such as EGS. Starting with just a few individuals, EGS have spread throughout the Lower Mainland and Victoria region. After an initial lag time following introduction, EGS took approximately 30 years to spread throughout each of the study areas. They have also been translocated to communities beyond but discontiguous from the two study areas. EGS are found significantly more often in residential areas than other land types. While EGS are rarely found in conifer forests, the general trend to replace conifer forest with residential development will facilitate their spread into areas that have previously acted as barriers to EGS distribution.

Some residents in British Columbia have observed the spread of EGS in the Lower Mainland and Victoria region with trepidation because introduced species can have negative impacts on native species. EGS are believed to impede the regeneration of Garry Oak and competitively displace native squirrels in both study areas. Neither of these hypotheses has been tested and it is possible that EGS have negative ecological impacts in British Columbia. There are reasons, however, to be optimistic. EGS are beneficial to hardwood tree regeneration, particularly oaks, in regions where EGS are native. EGS co-occur with North American Red Squirrels over large parts of North America through differences in habitat selection, so competitive displacement of Red Squirrels by EGS on Vancouver Island would not be expected to occur. Further, Northern Flying Squirrels, Douglas Squirrels, and EGS have continued to be present in Stanley Park for almost 100 years.

Regardless of whether EGS have a negative impact on native species in British Columbia, they are considered undesirable as a non-native species. In Europe, broad scale land management such as the maintenance of conifer woodlots rather than hardwoods has been recommended to limit populations of EGS (Kenward and Hodder 1998; Kenward et al. 1998; Bryce et al. 2002). The maintenance of conifer forests will also limit the spread of EGS in British Columbia. Education should also be a key component because translocations of EGS by humans have facilitated their spread across barriers such as bodies of water, mountains, and conifer forests.

Acknowledgments

This project required data over large study areas and I am thankful to the many sources that contributed data. Digital maps were made available through the Ministry

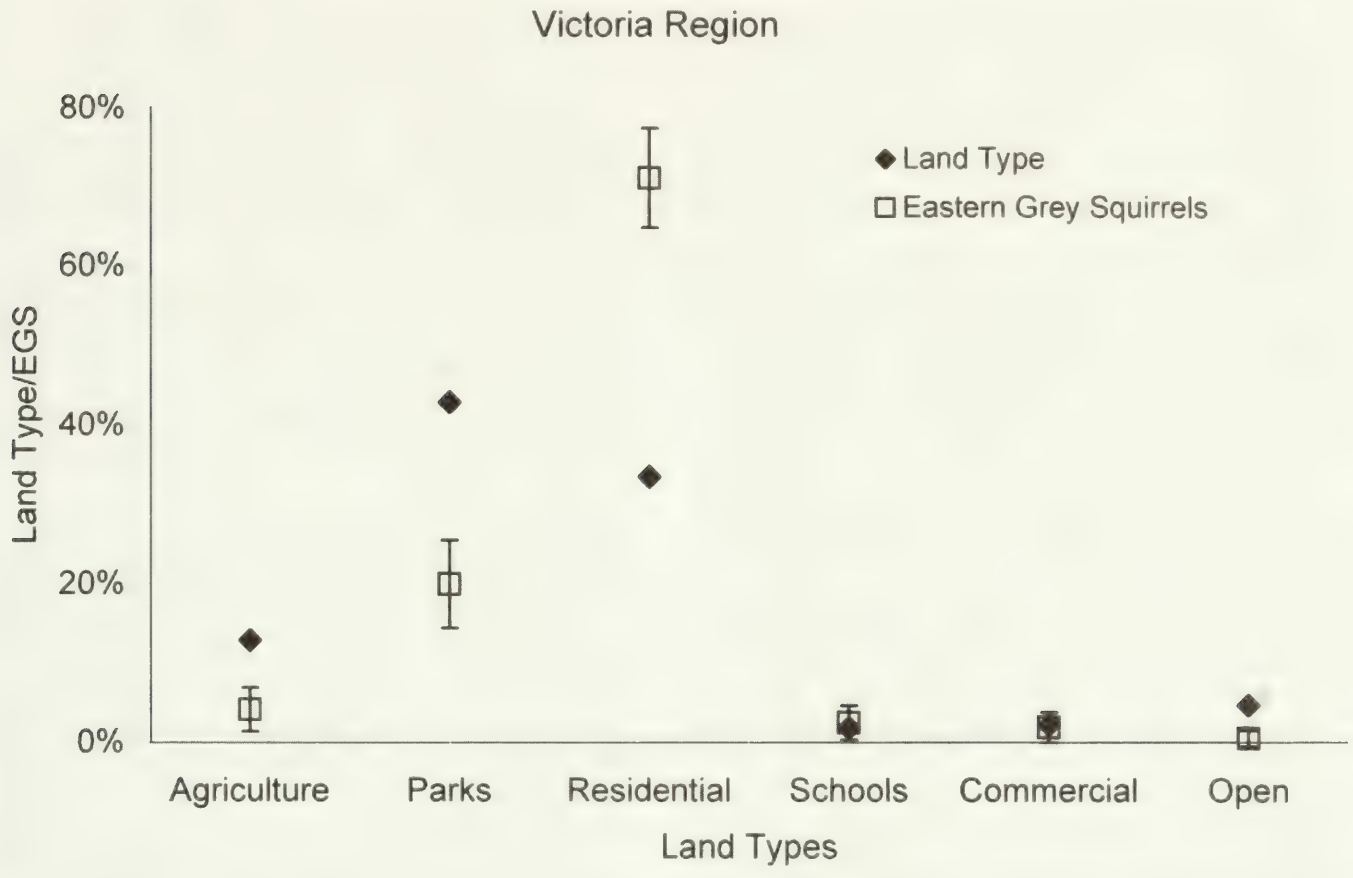

FIGURE 6. Habitat selection of Eastern Grey Squirrels in the Victoria region. The proportion of Eastern Grey Squirrels found in each land type with 95% confidence intervals ($\chi^2 << 0.001$, d.f. = 5). Eastern Grey Squirrels in the Victoria region were found predominately in *Residential* land types and not in *Agricultural*, *Open*, or *Parks* land types.

of Environment, Lands and Parks through the departments of the Crown Land Registry Services, Geographic Data BC, and the Strategic Planning Department of the Greater Vancouver Regional District. Undergraduate volunteers at Simon Fraser University and the University of Guelph were instrumental in data collection, field surveys, and data entry. The members of the Vancouver Natural History Society, the Burke Mountain Natural History Society, the White Rock Natural History Society, and the Victoria Natural History Society provided many of the squirrel locations. I appreciate the comments of Tom Nudds, Jane Reid, Simone Runyan, Peter Arcese, Isaac McEachern, and two reviewers who significantly improved earlier versions of the manuscript.

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Received 25 June 2003
Accepted 29 August 2005

The Fathead Minnow, *Pimephales promelas*, in New Brunswick

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A second record for the occurrence of the Fathead Minnow (*Pimephales promelas*) in New Brunswick, the first for the southwest portion of the province, is reported. This is the first documented occurrence of the species in the province in 44 years, and the first indication that the Fathead Minnow occurs outside the upper Saint John River system in New Brunswick.

Key Words: Fathead Minnow, *Pimephales promelas*, distribution, occurrence, habitat, St. Croix River, New Brunswick.

The Fathead Minnow (*Pimephales promelas*) is widely distributed in Canada (Scott and Crossman 1973), occurring from New Brunswick in the east, west through southern Quebec, all of Ontario, and large parts of Manitoba, Saskatchewan, Alberta, and a small area in the southern Northwest Territories. Various checklists and documents on fish species in New Brunswick identify the Fathead Minnow as occurring in the province (Scott and Crossman 1959, 1973; Gorham 1970s).

The status of the Fathead Minnow in New Brunswick has been uncertain, and sometimes a subject of debate, since it was first recorded here. Scott and Crossman (1959) reported the first record of the Fathead Minnow in New Brunswick waters. That record was based on the collection of two specimens in 1958 from an unnamed tributary to the Saint John River near Edmundston (Royal Ontario Museum Catalogue Number 19705).

Here, we report the collection of Fathead Minnows in southwestern New Brunswick during 2002. Based on the new records, it is important to alert researchers and fisheries resource managers of the potential for the species to be more widely distributed in the province than previously believed.

The Fathead Minnow is characteristically a small schooling species found in freshwater and brackish environments. The habitats associated with the species vary greatly throughout its range (Scott and Crossman 1973). It is found in lakes, ponds, and streams of varying sizes, ditches, reservoirs, and residual pools of intermittent streams, usually in sluggish or still water with a muddy bottom and abundant floating and submerged vegetation. The species is tolerant of high temperature, turbidity, low oxygen concentration, and high salinity.

Fathead Minnows were found at three sites in the watershed of a small unnamed tributary to the St. Croix River at St. Stephen, while conducting systematic electrofishing spot-checks for fish presence on 1 and 3 August 2002. All sites were located in settings that represented areas highly disturbed by human activities. Table 1 summarizes details of the settings and habitat characteristics at sites of the historical and new records.

The sites where Fathead Minnows were collected in 2002 are approximately 250 km from the location where they were collected in 1958 by Scott and Crossman (1959). Figure 1 shows the localities where Fathead Minnows have been documented in New Brunswick.

The Fathead Minnow was the only species of fish present at the three sites where it was collected in 2002. These sites are located upstream of Queensway Street (St. Stephen), in a section of stream with an average slope of 1.7%. A fourth site, sampled downstream of Queensway Street in a section of stream with an average slope of 7.2%, had a fish species assemblage that consisted of American Eel (*Anguilla rostrata*), Brook Trout (*Salvelinus fontinalis*), Creek Chub (*Semotilus atromaculatus*) and Lake Chub (*Couesius plumbeus*). The culvert under Queensway Street appears to be a barrier to upstream fish passage.

Six specimens of Fathead Minnows were captured at SC1, nine specimens at SC2, and one specimen at SC3. Fork length was measured for specimens at SC1 (range = 34-56 mm; mean = 40 mm) and SC2 (range = 32-61 mm; mean = 43 mm). One specimen retained from SC1 and two specimens from SC2 were deposited in the collections of the New Brunswick Museum (NBM), catalogued as NBM 1181 and NBM 1182, respectively. All other specimens were released back into the waters from which they were captured.

These new records raise questions related to the spotty distribution of populations of the Fathead Minnow in the province: are the recorded populations native or have they resulted from introductions of the species in some localities? Scott and Crossman (1973) identified the waters of western New Brunswick as being on the northeast fringe of the distribution range for the Fathead Minnow.

The Fathead Minnow has been recorded in approximately 100 lakes and ponds in the neighbouring State of Maine, occurring in all regions of the state (David Halliwell, Maine Department of Environmental Pro-

TABLE 1. Historical and new distribution records for the Fathead Minnow in New Brunswick. Preserved museum collections are noted: NBM = New Brunswick Museum; ROM = Royal Ontario Museum.

Site and Catalogue No.	Location Description	Date	Coordinates (Lat/Long)	Setting and Habitat	Sample Method
SJ1 (6(a)*) ROM 19705	Flood plain of creek between Saint John River and Highway 2, 8 miles south of Edmundston, NB	23 May 1958	47 19 44.63070N, 68 09 32.86147W	Water deep brown, visibility 10-15 inches; bottom hard mud; creek 10 feet wide, 4 feet deep	Seine, dip net
SC1 NBM 1181	Downstream of culvert under Route 725, St. Stephen, NB	1 August 2002	45 11 37.11892N, 67 18 53.61411W	Rural highway/residential; residual plunge pool, in intermittent stream, approximately 0.4 m deep; substrate of small gravel, sand, and mud, with small woody debris and detritus; water temperature 16° C	Electrofisher, dip net
SC2 NBM 1182	Downstream of culvert under St. Stephen Drive, St. Stephen, NB	3 August 2002	45 11 20.21655N, 67 18 39.21542W	Urban street/industrial park; quiet plunge pool approximately 1m deep; substrate of sand and mud, with detritus, emergent vegetation; water temperature 15° C	Electrofisher, dip net
SC3	Upstream of culvert under Queensway Street, St. Stephen, NB	3 August 2002	45 11 4.11048N, 67 17 36.36927W	Urban street/residential; sluggish stream approximately 0.4m deep; substrate of rock, gravel, sand and mud, with detritus, submerged vegetation; water temperature 18° C	Electrofisher, dip net

* Station designation assigned by Scott and Crossman (1959)

FIGURE 1. Distribution of the Fathead Minnow in New Brunswick. Locality designations correspond to those in Table 1.

tection, personal communication to DJH; Richard Jordan, Maine Department of Inland Fisheries and Wildlife, personal communication to DJH). Several of these locations occur in watersheds that drain to the Maine–New Brunswick boundary waters of the Saint John River or the St. Croix River systems. The waters in Maine where the Fathead Minnow has been recorded, nearest the sites in St. Stephen, are Upper and Lower Mud Lakes (Machias River watershed) and Orie Lake (St. Croix River watershed), located approximately 23 km southwest and 49 km northwest, respectively.

The records of occurrence of the Fathead Minnow in Maine are biased by the sampling effort associated with management of lakes that support important recreational fisheries for species of salmonids and smallmouth bass (*Micropterus dolomieu*). If sampling was expanded to other waters, it is believed that the Fathead Minnow would be found at other locations in

Maine (Richard Jordan, Maine Department of Inland Fisheries and Wildlife, personal communication to DJH).

Whittier et al. (2000) described the general distribution and native status of 24 minnow species in northeastern USA. They determined the Fathead Minnow to be native to the lakes where they collected it in central and northern Maine. However, the native status of this species has not been determined for the various locations where it has been recorded in the waters of eastern Maine (Richard Jordan, Maine Department of Inland Fisheries and Wildlife, personal communication to DJH). The Fathead Minnow is considered representative of intrastate introduced native fish species in Maine, as a result of illegal baitfish transplants (Halliwell 2003).

Live baitfish can be transported long distances. Consequently, bait-bucket transfer has been suggested as a major vector for illegal introductions and the occurrence of species in areas outside their native ranges (Litvak and Mandrak 1993, 2000; Rahel 2000). The use of baitfish for recreational fishing is widespread in Maine and the Fathead Minnow is a species commonly used (Richard Jordan, Maine Department of Inland Fisheries and Wildlife, personal communication to DJH). In New Brunswick, the use of baitfish is limited by provisions in the provincial angling regulations. The use or possession of live fish as bait is prohibited, except on tidal waters and on boundary waters between Maine and New Brunswick. On boundary waters, the only live fish that can be used or possessed for bait are fish taken from the waters being fished.

Due to the proximity of the St. Stephen sites to boundary waters where the Fathead Minnow could be used as a baitfish, its occurrence at these sites could be the result of a bait-bucket transfer. However, this is not certain with the information available.

In order to confirm the status of the 2002 records, the Atlantic Canada Conservation Data Centre (ACCDC) and various museums in eastern Canada were contacted to determine if they hold unreported data or collections of the Fathead Minnow from New Brunswick. The ACCDC reported that there were no records of the Fathead Minnow in New Brunswick other than that reported by Scott and Crossman in 1959 (Kate Bredin, ACCDC, personal communication to DJH). Consultation with representatives from Canadian and major regional museums confirmed that they hold no unreported collections of the Fathead Minnow from the province (Sylvie Laframboise, Canadian Museum of Nature, personal communication to DJH; Donald McAlpine, New Brunswick Museum, personal communication to DJH; John Gilhen, Nova Scotia Museum of Natural History, personal communication to DJH; Erling Holm, Royal Ontario Museum, personal communication to DJH).

The lack of additional occurrence records for the Fathead Minnow in New Brunswick might be a reflection of the actual distribution of the species in the province, or perhaps a lack of effort among some fisheries field personnel to distinguish between the numerous species of minnows encountered. Historically, individual species of minnows have been given little attention in fisheries surveys, often being lumped together into the generic category of "minnows" (Whittier et al. 2000).

The new records in 2002 indicate the potential for the species to be more widely distributed in the province than previously believed. It is unknown if the populations of the Fathead Minnow at St. Stephen are native to southwestern New Brunswick, or if they have been introduced.

Acknowledgments

We express our thanks to Adam Carr for assistance in the field. Donald McAlpine, Curator of Zoology, New Brunswick Museum, verified identification of the specimens collected during 2002. Erling Holm, Assistant Curator of Fishes, Royal Ontario Museum provided verification of identification of specimens catalogued as ROM 19705. Dan McDonald, Dillon Consulting Limited, prepared the location map.

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Received 16 July 2003
Accepted 1 June 2005

Vision and its Relationship to Novel Behaviour in St. Lawrence River Greenland Sharks, *Somniosus microcephalus*

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Harvey-Clark, Chris J., Jeffrey J. Gallant, and John H. Batt. 2005. Vision and its relationship to novel behaviour in St. Lawrence River Greenland Sharks, *Somniosus microcephalus*. Canadian Field-Naturalist 119(3): 355–359.

Rarely observed Greenland Sharks, *Somniosus microcephalus*, were recorded at shallow depths by divers employing underwater video in the St. Lawrence River, in association with a seasonal concentration of Capelin (*Mallotus villosus*) in May-June 2003. We recorded unique proximity-induced display motor patterns in these sharks, which have not been recorded in underwater observations of Arctic Greenland Sharks. Arctic sharks have a high incidence of blindness due to an ocular copepod parasite, *Ommatokoita elongata*. The absence of parasite-induced blindness in St. Lawrence Greenland Sharks, in contrast to endemic blindness in the Arctic population, may allow sharks in this region to more readily visually recognize the presence of conspecifics and potential prey. Improved visual acuity may therefore allow St. Lawrence River sharks to express a different behavioural repertoire than Arctic sharks, with resulting changes in intra- and inter-specific aggression and predatory behaviour.

Key Words: Chondricthyes, Squaliformes, Somnosidae, Greenland Shark, *Somniosus microcephalus*, display behaviour, copepod, *Ommatokoita elongata*.

The Greenland Shark, *Somniosus microcephalus* (Bloch and Schneider 1801) has seldom been observed under natural conditions, and until this report, had been observed by divers underwater only rarely in Arctic waters (Caloyianis 1998). This giant member of the elasmobranch Order Squaliformes is a slow moving, primarily deep water shark reaching at least 6.4 metres in length (Compagno 1984), found in circumpolar regions and in cold, deep water to depths of at least 2200 metres (Herendorff and Berra 1995). Greenland Shark stomachs contain a wide range of prey including marine invertebrates, fish and mammals as well as terrestrial vertebrates such as Caribou *Rangifer tarandus* (Compagno 1984), and the role of this species as a predator, or primarily a scavenger, of marine mammals is controversial (Bigelow and Schroeder 1953; Ridoux et al. 1998; Lucas and McAlpine 2002).

St. Lawrence River Greenland Sharks free of the ocular copepod parasite *Ommatokoita elongate* were observed by divers during an unusual inshore migration associated with seasonal concentrations of Capelin *Mallotus villosus*. Here we report on closely approached sharks that exhibited display motor patterns not previously described in this species.

Methods

We employed SCUBA and underwater video in the region of Baie-Comeau, Quebec, Canada (49°16.9'N, 68°07.2'W, Figure 1), to record Greenland Shark size, sex, physical condition, swimming speed and behaviour in May and June 2003. The occurrence in inshore waters of this elusive species was accompanied by an unusually high seasonal inshore concentration of Capelin (*Mallotus villosus*) massing around docks and bottom structures which was the highest recorded in the region over the previous five years (F. Gregoire, Canadian Department of Fisheries and Oceans, Institute Maurice Lamontaigne, Mont-Joli, Quebec, personal communication 2003). Both juvenile Harbour Seal *(Phoca vitulina)* and Grey Seal *(Halichoerus grypus)*, potential prey species of the sharks, were locally abundant and were observed during fieldwork and diving activities.

Observations were made between 09:00 and 17:30 Eastern Standard Time and occurred in seawater depths from 10.0 to 28.0 m (mean=18.1 m +/- 5.8 m 95% confidence interval, CI). Seawater temperatures ranged from 1.0°C to 9.0°C (mean= 4.4°C +/- 3.1°C 95% CI). We employed a standard report form and interviewed local professional divers, who first reported the presence of sharks in the region.

Videotape of sharks was analyzed for size scale using adjacent objects of known maximum size (Plumose Anemones, *Metridium senile*, maximum height of 40 cm) and visible time code (hours/minutes/seconds) to determine swimming speed. We recorded 68.2 video minutes during prolonged encounters with four sharks over a three-day period and documented six other encounters occurring between 26 May and 12 June 2003 in the same region.

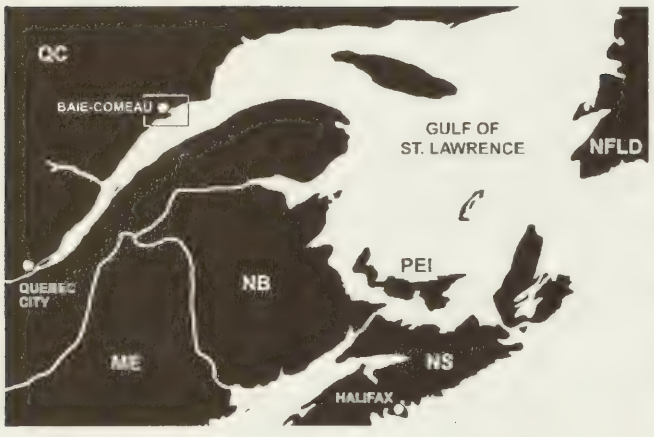

FIGURE 1. Location of Greenland Shark sightings in the St. Lawrence River in the vicinity of Baie-Comeau, Province of Quebec.

FIGURE 2. The rostrum of a female Greenland Shark illustrating typical loss of pigmentation seen anterior and adjacent to prominent nares. The cornea lacking attached parasitic copepods, and the dorsal operculum are clearly visible.

Results

Of the 10 shark encounters, the range in estimated length was from 2.5 to 4.5 m total length (mean = 2.8 m +/- 0.34 m CI 95%). In four sharks sex was determined (3 female, 1 male), with one markedly "girthy" 3.0 m female shark believed to be gravid. In one instance three sharks were seen separately on the same dive and in one instance two sharks were observed simultaneously within 5 meters of each other on diverging courses. Shark swimming speeds ranged from 0.10 m/s to peak at 1.40 m/s (mean = 0.62 m/s +/- 0.31 m/s 95% CI). Greenland Sharks were capable of rapid acceleration from 0.10 m/s to 1.40 m/s and could outpace divers when swimming in a straight line, were highly manoeuvrable and were capable of changing depth and direction rapidly. In one case, the same 2.50 m female shark identified by scar patterns was seen repeatedly over a 3-day period in the same location, in each case within 50 m of the same position when encountered. Female sharks were noted to have more scarring than males, generally linear scarring on the tail, pectoral fins and dorsum of the caudal peduncle. We postulate that these scars may have resulted from nuptial or combat related behaviour, as observed in other shark species (Compagno 1984).

Both sexes exhibited a whitish cruciate pattern which appears to be a loss of pigmentation on the anterior rostrum, and which may be the result of bottom foraging activities using the rostrum (Figure 2). A male shark was noted to have a single left clasper, although this species generally possesses two claspers (Compagno 1984).

During encounters sharks were found swimming approximately 1.0 to 2.0 meters above the substrate towards divers on converging courses, and following close approach swam on sinusoidal courses, in some cases performing complete or half circle manoeuvres over a wide radius (20 to 30 m). These circling manoeuvres resulted in sharks maintaining continuous eye contact with divers, and in two instances sharks left the bottom to ascend upwards at an acute angle and closely approach a diver above them in mid-water, apparently in investigative fashion.

When sharks were closely approached from the lateral or anterior aspect (2.0 m or less from the eye), they initially displayed a motor pattern which included rapid bilateral ventral deflection of the pectoral fins (Figure 3 a, b), deceleration, and adoption of a

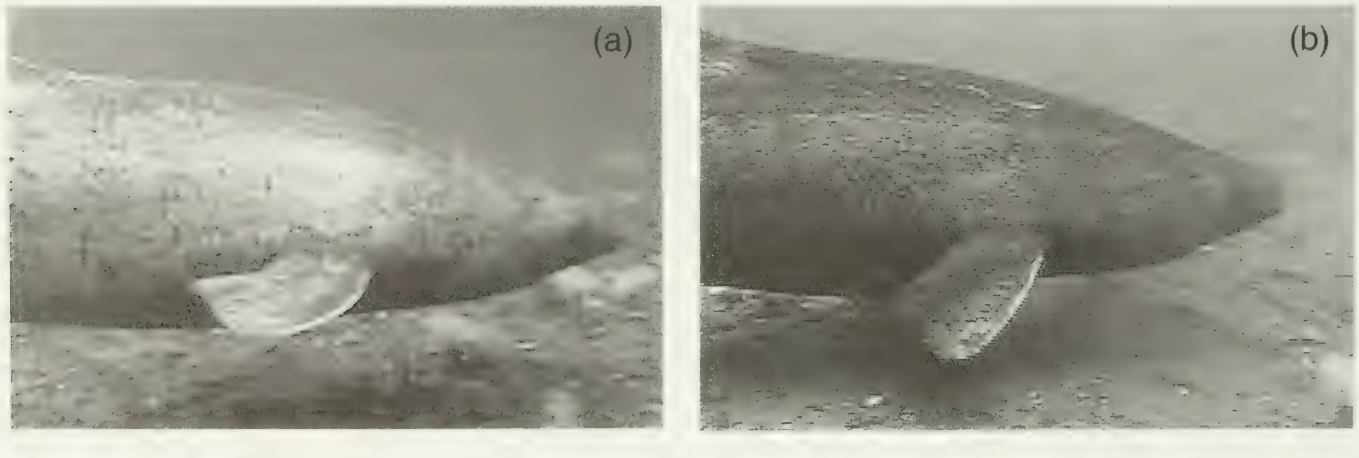

FIGURE 3. Female Greeland shark showing (a) normal pectoral fin position and (b) marked ventral deflection of pectoral fins as part of a motor pattern observed consistently when closely approached by divers.

head-down attitude with the front of the animal 0.1-0.3 m above the substrate, the trunk slanted upward and the tail held higher off the bottom, the dorsum curved upward, the axis of the body being held approximately 10 degrees off horizontal, and the mouth held slightly open (Figure 4). This posture was maintained from one to several seconds, after which the shark would accelerate and swim away from the diver or change course to avoid the diver. This motor display was repeatedly exhibited by the four sharks we observed when closely approached.

FIGURE 4: Male Greenland Shark posturing, exhibiting curvature of the dorsum, having just shown rapid downward flexion of head and tail, contacting the silt-covered substrate, which caused the visible cloudiness ahead of and behind the animal. This motor pattern was elicited in response to presence and close proximity of divers.

Discussion

Arctic Greenland Shark populations have high infection rates with the ocular copepod parasite *Ommatokoita elongata* (Grant, 1827), which has been found in up to 98.9 percent of individuals in surveyed populations (Berland 1961), and in 100 percent of individuals in a recent tracking study off Baffin Island (Skomal and Benz 2004). Based on histopathological findings in copepod-parasitized eyes, Borucinska et al. (1998) postulated that sharks infected with ocular *Ommatokoita* were likely to be blind. However, the sharks we observed were free bilaterally of external signs and lesions of this parasite, had clear corneal epithelium, showed definite visual orientation to divers, tracked divers with horizontal and vertical eye movement, repeatedly demonstrated visual avoidance of divers and objects on the bottom, and repeatedly exhibited the described behaviour when closely approached. Vision is thought to be a major sense for investigative and social behaviour, prey recognition and predation motor patterns in the majority of shark species (Gruber 1977). The visual acuity of the non-parasitized sharks we observed in the St. Lawrence River may have profound implications for the social behaviour and patterns of predation of this population. The reason these sharks have relatively low ocular copepod infestation rates compared to Arctic populations is unclear, and may relate to parasite abundance and ecology, host factors such as population density, nutrition and immune status, and/or environmental conditions such as dispersion currents, seawater salinity and temperature.

Our perception of this species as a predator of benthic fishes and a sluggish, blind, olfactory scavenger of marine mammal carcasses, with an important ecological role as a mammal "carcass opening" species in Arctic deep water ecosystems (Snelgrove and Smith 2002) has changed as a result of these first-hand observations. Though descriptions of active predation by Greenland Sharks have not been reported in the scientific literature, there is evidence that this species is capable of actively stalking and killing marine mammals as well as scavenging the carcasses of marine mammals. Ridoux et al. (1998) documented a freshly killed juvenile Ringed Seal, *Phoca hispida* (Schreber, 1775), with bite marks across the chest, found in the stomach of a 4.5 m Greenland Shark off Iceland. Our underwater observations support the contention that large, stealthy Greenland Sharks are capable of rapid manoeuvring, moderate speed swimming and potential predation of infirm, sleeping (Ridgway et al. 1975), or predator-naïve juvenile seals. This population of sharks is visual and can avoid or seek divers visually, and using other senses in conditions of poor visibility, and we advise caution when diving under low visibility conditions in areas where these sharks are known to occur. St. Lawrence River Greenland Sharks remain in the same shallow water area for multiple days, repeatedly revisit novel potential prey items in the environment, ascend from the bottom to investigate divers in mid-water, circle and maintain constant visual contact with divers rather than fleeing, and exhibit unusual motor display patterns when approached closely by divers. These findings are consistent with the behaviour of a shark species which has the potential to act as an opportunistic predator as well as a scavenger.

Acknowledgments

The authors gratefully acknowledge the assistance of Alain Simard, Jean-Yves Forest and Sylvain Sirois.

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Received 6 November 2003
Accepted 10 May 2005

Charactéristiques d'une population introduit du Grand brochet, *Esox lucius,* dans le lac Ramsay, Parc de la Gatineau, Québec, et impact sur l'ichtyofaune

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Vachon, Josiane, Brigitte F. Lavallée, et François Chapleau. 2005. Charactéristiques d'une population introduit du Grand brochet, *Esox lucius*, dans le lac Ramsay, Parc de la Gatineau, Québec, et impact sur l'ichtyofaune. Canadian Field-Naturalist 119(3): 359–366.

En 1995, la présence du Grand brochet (*Esox lucius*), une espèce piscivore, a été notée pour la première fois dans le lac Ramsay, Parc de la Gatineau (Québec). Il a été déterminé que l'espèce a été introduite après l'été 1991. Un échantillonnage exhaustif de l'ichtyofaune du lac en 2001 et 2002 a permis de constater que trois des 17 petites espèces de poissons du lac sont probablement disparues: le Mulet perlé (*Margariscus margarita*), l'Épinoche à cinq épines (*Culaea inconstans*) et une forme rare de l'Épinoche à trois épines (*Gasterosteus aculeatus*). Il est prédit que plusieurs autres espèces pourraient disparaître au cours des prochaines années. La croissance du Grand brochet dans le lac Ramsay est comparable aux autres lacs du sud du Québec. En 2001, le rapport femelles:mâles était de 15 : 1, une valeur anormale et inexpliquée.

Mots clés: *Esox lucius*, Grand brochet, introduit, piscivore, croissance, petits lacs, Parc de la Gatineau.

In 1995, the Northern Pike (*Esox lucius*), a piscivorous fish, was captured for the first time in Ramsay Lake, a small lake of the Gatineau Park (Québec). It was determined that this species was introduced after the summer of 1991. An exhaustive survey of the ichthyofauna of this lake in 2001 and 2002 indicated that three of the 17 small-bodied species of the lake have probably disappeared: the Pearl Dace (*Margariscus margarita*), the Fivespine Stickleback (*Culaea inconstans*) and a special form of the Threespine Stickleback (*Gasterosteus aculeatus*). It is predicted that several other species may be extirpated in the next few years. Northern Pike growth in the lake is comparable to other values obtained for other southern Québec lakes. In 2001, the female:male ratio was highly unbalanced and difficult to explain at 15 : 1.

Key Words: *Esox lucius*, Northern Pike, introduction, piscivory, growth, small lakes, Gatineau Park.

L'introduction d'espèces exotiques de poissons perturbe les communautés animales aquatiques (He et Kitchell 1990; Chapleau et al. 1997; Knapp et Matthews 2000; Economidis et al. 2000; Rahel 2000; Huckins et al. 2000; Findlay et al. 2000). Les petits lacs nordiques sans poissons piscivores de l'Amérique du nord comptent beaucoup moins de petites espèces de poissons que les lacs avec piscivores (Tonn et Magnuson 1982; Robinson et Tonn 1989; Tonn et al. 1992). De plus, l'introduction d'une espèce piscivore dans un lac sans piscivore entraîne inexorablement la disparition de plusieurs petites espèces (Chapleau et al. 1997; Whittier et al. 1997; Whittier et Kincaid 1999; Findlay et al. 2000). Ces espèces sont éliminées des petits lacs parce que toutes les classes d'âge sont vulnérables à la prédation et qu'elles ne peuvent pas trouver un refuge contre l'action prédatrice des poissons piscivores (Tonn et al. 1992). Le cadre temporel du processus d'extinction locale suite à l'introduction de piscivores n'a été que peu étudié (voir Demers et al. 2001a and 2001b). En effet, la plupart des études n'ont documenté que le fait accompli, souvent plusieurs décennies après l'introduction initiale des piscivores (Chapleau et al. 1997; Whittier et Kincaid 1999; Findlay et al. 2000).

Le lac Ramsay est un lac de 10,3 hectares qui a été inclus dans une étude sur l'impact de l'introduction (vers 1908) d'espèces piscivores sur les communautés de poissons des petits lacs du Parc de la Gatineau (Chapleau et al. 1997). En 1991, ce lac sans piscivores contenait 17 espèces dont 12 espèces de petite taille (incluant 10 cyprinidés). De fait, ce lac présentait l'ichtyofaune la plus diversifiée des petits lacs (moins de 60 hectares) du Parc de la Gatineau. À l'automne 1995, des spécimens d'une espèce piscivore, le Grand brochet (*Esox lucius*), ont été capturés dans le lac Ramsay. Le plus vieux spécimen étant âgé de cinq ans, nous constatons donc qu'une introduction non-autorisée de Grands brochets a été faite après l'été 1991. Depuis, des échantillonnages (1998, 1999, 2001 et 2002) ont révélé que le Grand brochet était bien établi dans le lac Ramsay.

Le premier objectif de notre étude est de déterminer si l'introduction d'une espèce piscivore après l'été 1991 a eu un impact sur le nombre d'espèces de poissons de petite taille dans le lac Ramsay. Un échantillonnage intensif des espèces du lac en 2001 et 2002 a permis de répondre à cette question. Le deuxième objectif de notre étude est d'examiner les paramètres biologiques de la population de Grand brochet (croissance, coeffi-

cient de condition, ratio des sexes) dans le lac Ramsay. Il est postulé que le Grand brochet montrera une croissance particulièrement rapide dans ce lac du fait qu'il se retrouve dans un habitat qui possède une grande abondance de petits poissons et aucun autre piscivore.

Matériel et méthode

Le lac Ramsay (45°35'54"N, 76°06'00"O; profondeur maximale : 9,5 m; profondeur moyenne : 4,1 m) est un petit lac du bouclier canadien à 200 m au-dessus du niveau de la mer. Son littoral est caractérisé par une abondance de plantes aquatiques mais également par des zones couvertes de sphaigne ainsi que des plages de sable et gravier. Le site est fréquenté irrégulièrement par des campeurs l'été et des pêcheurs l'été comme l'hiver (observation personnelle).

Le tableau 1 énumère les 17 espèces de poissons trouvées dans le lac en 1991 (Chapleau et al. 1997). Cette liste provient d'un échantillonnage fait en 1991 et est combinée à une liste d'espèces publiée par Rubec (1975). En 1991, le lac contenait une forme relativement rare d'Épinoche à trois épines (*Gasterosteus aculeatus*). Il s'agit d'une forme habituellement anadrome qui présente une série de plaques osseuses le long du corps et qui a pénétré dans la région en même temps que la mer Champlain (McAllister et Coad 1974). Elle est également restée prisonnière des lacs Hawley, Kidder, Pink et Canard suite au retrait des glaciers (Wisconsin) (Rubec 1975).

Des échantillonnages exhaustifs de la communauté de poissons du lac Ramsay ont été faits en 1971 (Rubec, 1975), 1991 (Chapleau et al. 1997), 2001 et 2002. En 1995 et 1998, l'échantillonnage était surtout axé vers la capture de Grands brochets. En 1995, des Grands brochets furent capturés au filet maillant dans le cadre d'un cours de biologie (Université d'Ottawa). Les mesures ainsi que les cleithra des poissons ont été conservés. En 1998, les engins de pêche comprenaient: trois filets maillants expérimentaux (50 m × 1,8 m avec mailles variant entre 2,5 et 15 cm) et un filet trémail (37 × 1.2 m; panneau extérieur avec mailles de 20 cm et panneau intérieur avec mailles de 2,5 cm) et deux verveux (aile de 9,1 m × 0,9 m avec anneaux de 76 cm de diamètre, mailles de 6 mm). En février 1999, 20 brimballes ont été utilisées pendant deux jours (8 heures par jour). Elles étaient réparties également dans les deux sites où les captures ont été les plus nombreuses l'automne précédant. Un seul Grand brochet a été capturé lors de la pêche hivernale. Ce spécimen n'a pas été inclus dans les analyses. En 2001, nous avons utilisé les mêmes filets qu'en 1998 et la période de pêche active a été de 72 heures (24 heures du 19 au 21 septembre et 48 heures du 27 au 29 septembre). Tous les Grands brochets capturés ont été sacrifiés, rapportés au laboratoire dans des glacières et congelés. Les spécimens d'autres espèces capturées dans les filets (Barbotte brune, *Ameiurus nebulosus,* et Meunier noir, *Catostomus commersoni*) ont été remis à l'eau. L'échantillonnage des poissons de petite taille (surtout des cyprinidés) en 2001 a été fait en utilisant une seine à bâtons de 10 m de longueur et deux verveux (diamètre de l'ouverture: 76 cm; ailes 9 m). En 2002, seulement la seine a été utilisée. Les poissons de petite taille ont été remis à l'eau sauf pour quelques spécimens qui ont été conservés pour la confirmation d'identification en laboratoire. Un seul Grand brochet (0+) a été capturé et il n'est pas inclus dans les analyses. L'effort d'échantillonnage des petites espèces en 2001 et 2002 était plus élevé qu'en 1991. En 1991, nous avons échantillonné une surface de 300 m^2 avec la seine alors que les verveux ont été actifs pendant 260,25 heures. En 2001 et 2002, l'échantillonnage par la seine a couvert une surface de 3043 m^2 alors que les verveux ont été laissés dans l'eau pendant 70,25 heures. Il faut noter qu'aucune espèce n'a été échantillonnée uniquement par les verveux en 1991, 2001 et 2002, ce qui suggère que la seine est le meilleur engin de pêche pour la capture des petites espèces. Nous avons donc échantillonné une surface 10 fois plus grande en 2001 et 2002 qu'en 1991.

Tous les Grands brochets ont été décongelés avant d'être pesés et mesurés (longueurs totale et standard). Un examen visuel des gonades a permis d'identifier le sexe des spécimens. Le contenu stomacal a été examiné et les proies ont été identifiées lorsque cela était possible. Les deux cleithra ont été disséqués et bouillis. La détermination de l'âge a été faite en comptant les annuli sur les cleithra selon la méthode décrite par Casselman (1979). Les âges ont été confirmés par deux auteurs. Afin de faire des rétrocalculs de la longueur des individus à tous les âges, les distances entre le foyer et les annuli ainsi qu'entre le foyer et le bord des cleithra ont été mesurées.

Le coefficient de condition des populations a été déterminé en calculant la pente de la relation entre les logarithmes de la masse et de la longueur totale (Tesh 1971 et Ricker 1979 dans Wootton 1998).

Résultats

Ichtyofaune

En 2001 et 2002, nous avons capturé 14 espèces de poissons (sans compter le Grand brochet), soient trois de moins que lors de l'échantillonnage de la communauté de 1991 alors qu'il n'y avait pas de Grands brochets dans le lac (tableau 1). Les espèces manquantes sont le Mulet perlé (*Margariscus margarita*), l'Épinoche à trois épines (*Gasterosteus aculeatus*) et l'Épinoche à cinq épines (*Culaea inconstans*). Certaines espèces ont été capturées en très petit nombre : le Méné laiton (*Hybognathus hankinsoni*), le Ventre citron (*Phoxinus neogaeus*) et l'hybride entre le Ventre rouge du nord (*Phoxinus eos*) et le Ventre citron. Cependant, les difficultés d'identification des spécimens appartenant au complexe *Phoxinus eos* × *Phoxinus neogaeus* nous empêchent de conclure quoi que ce soit à propos de ces espèces. Les espèces les plus communes dans le lac sont la Barbotte brune (*Ameiurus nebulosus*), le Crapet-soleil (*Lepomis gibbosus*), la Chatte de l'est

TABLEAU 1. Liste des espèces de poissons dans le lac Ramsay, Parc de la Gatineau, en 1991 et en 2001-2002.

Espèces capturées lors de l'échantillonnage de 1991		Espèces présentes
Nom latin	Nom commun	en 2001 et 2002)
Esox lucius[1]	Grand brochet	x
Umbra limi	Umbre de vase	x
Hybognathus hankinsoni	Méné laiton	x
Notemigonus crysoleucas	Chatte de l'Est	x
Luxilus cornutus	Méné à nageoires rouges	x
Notropis heterolepis	Museau noir	x
Phoxinus eos[2]	Ventre rouge du nord	x
Phoxinus neogaeus[2]	Ventre citron	x
Pimephales notatus	Ventre-pourri	x
Pimephales promelas	Tête-de-boule	x
Semotilus atromaculatus	Mulet à cornes	x
Margariscus margarita	Mulet perlé	
Catostomus commersoni	Meunier noir	x
Ameiurus nebulosus	Barbotte brune	x
Lepomis gibbosus	Crapet-soleil	x
Etheostoma exile	Dard à ventre jaune	x
Culaea inconstans	Épinoche à cinq épines	
Gasterosteus aculeatus	Épinoche à trois épines	

[1] *Esox lucius* n'a pas été capturé en 1991.
[2] S'hybride de *Phoxinus eos* et de *Phoxinus neogaeus* était également présent lors de cets échantillonnage.

(*Notemigonus chrysoleucas*) et le Meunier noir (*Catostomus commersoni*).

Parmi les Grands brochets capturés en 2001, 28% avaient l'estomac vide, 41% avaient un contenu digéré et 31% contenaient des poissons ou autres animaux non digérés. Trois des Grands brochets avaient des parties d'écrevisses, un avait capturé un petit rongeur et un autre une grenouille. Parmi les poissons consommés encore identifiables, on a noté la présence de Chattes de l'est et de Museaux noirs. Ces dernières espèces ont été capturées lors de notre échantillonnage.

Croissance du Grand brochet

À l'automne 1995, 1998 et 2001, nous avons capturé respectivement 11, 34 et 32 Grands brochets. Le nombre de captures par unité d'effort de pêche (ou capture/heure de pêche active × nombre de filets) de 1998 et 2001 étaient respectivement de 0,095 et 0,099. Le nombre de Grands brochets capturés par unité d'effort (UE) a diminué lors des deux derniers jours de pêche au filet maillant en 2001. Il était de 0,15 et 0,186 Grand brochet par UE pour les deux premiers jours de pêche, puis de 0,03 Grand brochet par UE lors des deux derniers jours.

Tous les individus étaient âgés entre 0+ et 7+ (Tableau 2). Les cleithra dont le premier annulus n'était pas visible n'ont pas été utilisés pour le rétrocalcul de la longueur à l'âge d'un an. Les pentes des régressions entre la longueur et la masse (coefficient de condition) étaient de 3,14, 3,07 et 2,93 pour 1995, 1998 et 2001 respectivement (figure 1). Lors de la pêche hivernale de 1999, le seul Grand brochet capturé était âgé de deux ans. En juillet 2002, un Grand brochet 0+ (longueur totale = 12,4 cm, masse totale = 9,8 g) a été capturé avec la seine.

Les longueurs moyennes rétrocalculées des Grands brochets à chaque âge et à chaque année de capture sont présentées à la figure 2. Il y a généralement une différence significative entre les longueurs moyennes rétrocalculées des Grands brochets pour chaque année de capture, sauf lorsque les spécimens étaient âgés de trois ans (ANOVA: alpha = 0,05; F = 0,528; p = 0,593). À un an, toutes les longueurs moyennes étaient significativement différentes (ANOVA: alpha = 0,05; F = 60,105; p < 0,000). À deux ans, les Grands brochets capturés en 2001 avaient une longueur moyenne significativement plus élevée que les spécimens capturés en 1995 ou 1998 (ANOVA: alpha = 0,05; F = 12,912; p < 0,000; $p_{Bonferroni}$ de 1995 et 1998 < 0,000). À quatre et cinq ans ($ANOVA_{4ans}$: alpha = 0,05; F = 5,765; p = 0,007 et $ANOVA_{5ans}$: alpha = 0,05; F = 8,058; p = 0,003), la longueur moyenne des Grands brochets capturés en 2001 était significativement supérieure à celle des spécimens capturés en 1998 ($ANOVA_{4ans}$: alpha = 0,05; $p_{Bonferroni}$ = 0,007; $ANOVA_{5ans}$: alpha = 0,05; $p_{Bonferroni}$ = 0,002).

Rapport femelles : mâles (F : M)

En 2001, sur un total de 32 Grands brochets capturés, seulement deux étaient des mâles (rapport F:M de 15 : 1). Ce rapport était de 1,2 : 1 en 1995 alors qu'il était à de 5,8 : 1 en 1998.

Discussion

Ichtyodiversité

Le Grand brochet a été introduit dans le lac Ramsay après l'été 1991. Depuis ce temps, trois espèces de poissons (Mulet perlé, Épinoche à trois épines et Épinoche à cinq épines) sont probablement disparues du lac

TABLEAU 2. Longueur et masse totales moyennes, minima et maxima pour chaque année d'échantillonnage et chaque classe d'âge pour les Grands brochets (*Esox lucius*) du Parc de la Gatineau. Le nombre de captures (femelles : mâles) est également indiqué.

Année	Âge (ans)	Longueur totale min – max (cm)	Longueur totale moyenne ± écart-type (cm)	Masse totale min – max (g)	Masse totale moyenne ± écart-type (g)	Femelles : Mâles
1995	3+	52.0 – 67.7	56.7 ± 6.8	983.0 – 2419.0	1561.5 ± 591.4	4 : 2
	4+	50.0 – 72.0	61.7 ± 10.7	1006.0 – 2947.0	1918.0 ± 952.3	2 : 2
	5+[1]	–	61.7	–	1939.0	0 : 1
1998	1+	33.5 – 37.1	35.4 ± 1.8	230.0 – 309.0	272.0 ± 39.7	3 : 0
	2+	34.7 – 41.2	38.1 ± 2.2	271.0 – 444.0	353.8 ± 55.1	10 : 2
	3+	56.4 – 58.4	57.4 ± 1.4	1179.0 – 1317.0	1248.0 ± 97.6	2 : 0
	4+	56.1 – 63.3	59.3 ± 3.7	1222.0 – 1645.0	1368.3 ± 239.7	2 : 1
	5+	58.3 – 64.8	61.8 ± 2.2	1330.0 – 1879.0	1541.8 ± 192.2	8 : 2
	6+	56.0 – 58.5	57.3 ± 1.8	1092.0 – 1423.0	1257.5 ± 234.0	2 : 0
	7+	66.5 – 71.1	68.8 ± 3.2	1890.0 – 2427.0	2158.5 ± 379.7	2 : 0
1999	3+ [1]	–	49.5	–	786	0 : 1
2001	1+[1]	–	41.5	–	427.0	1 : 0
	2+	42.4 – 50.5	46.2 ± 2.3	445.0 – 871.0	605.6 ± 115.1	13 : 1
	3+	51.0 – 54.0	52.2 ± 1.3	807.0 – 1014.0	883.0 ± 97.3	3 : 1
	4+	58.5 – 68.9	64.5 ± 4.5	873.0 – 2213.0	1502.0 ± 546.9	5 : 0
	5+	64.2 – 71.7	67.3 ± 2.8	1549.0 – 2308.0	1862.9 ± 288.1	8 : 0
2002	0+ [1]	–	12.4	–	9.8	1 n/d

[1] Ces classes d'âge n'ont qu'un seul poisson.

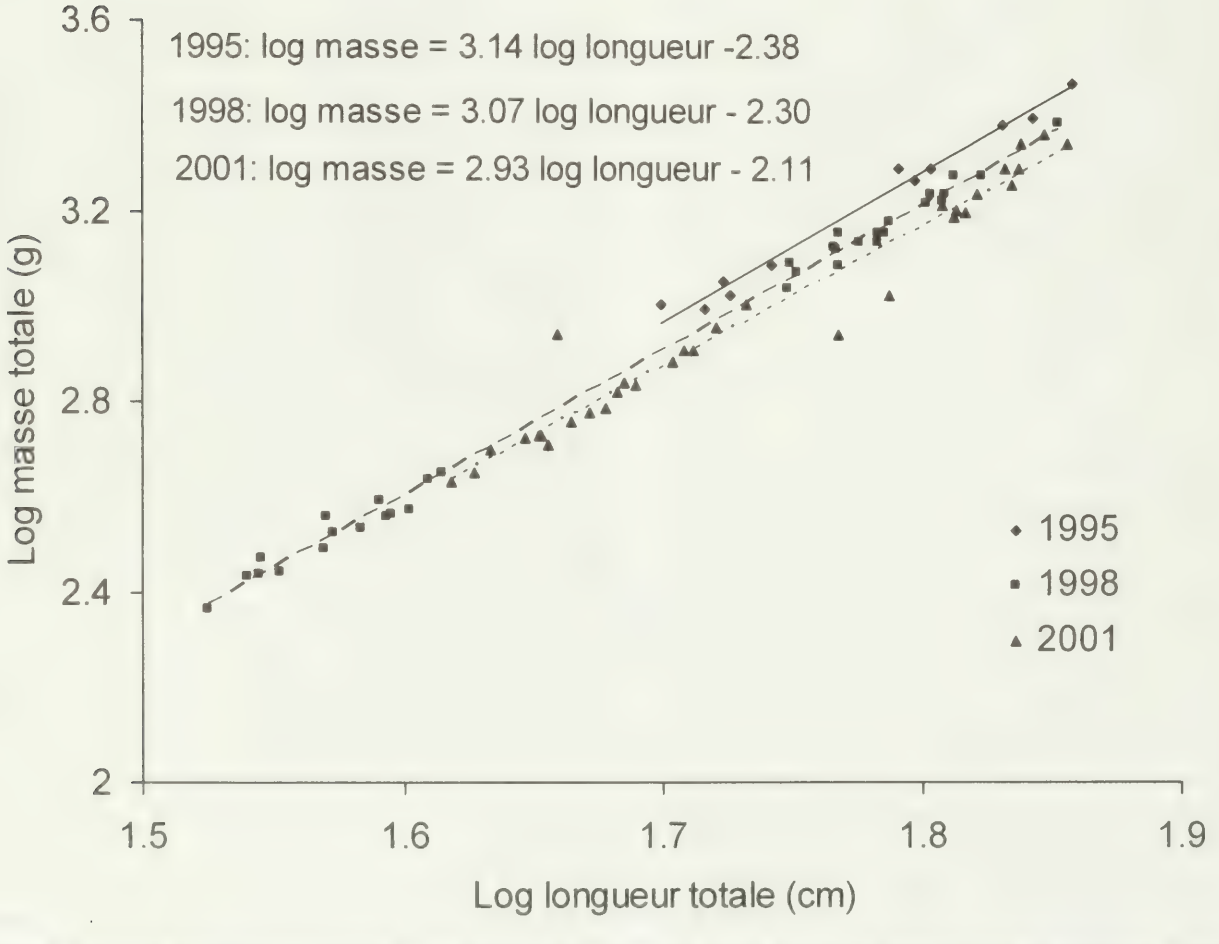

FIGURE 1. Relation logarithmique entre la masse totale et la longueur totale des Grands brochets du lac Ramsay. Le coefficient de condition correspond à la pente des droites. 1995 : n = 11 ; 1998 : n = 34 ; 2001 : n = 32.

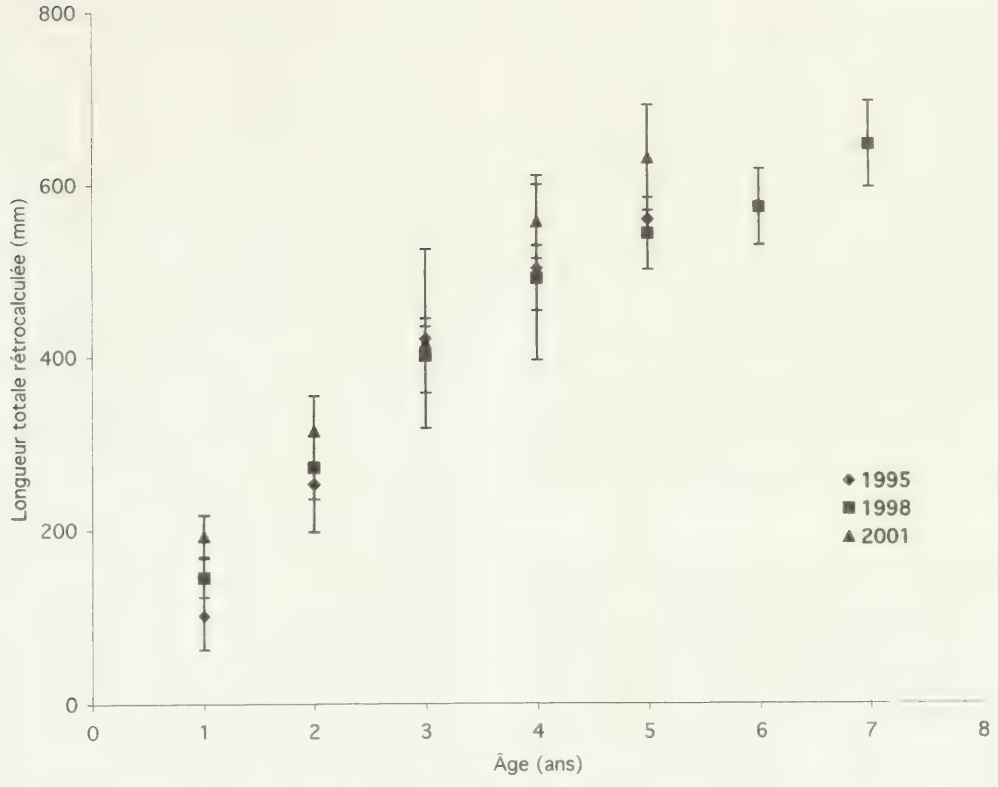

FIGURE 2. Longueur rétrocalculée à chaque âge des Grands brochets du lac Ramsay lors des années d'échantillonnage (1995, 1998, 2001). Les barres d'erreurs représentent les écarts-types.

Ramsay. Leur présence dans le lac est possible mais dans ce cas, elle reste indétectable même suite à un effort d'échantillonnage plus intensif en 2001 et 2002 qu'en 1991. Il est probable que la cause de l'absence de ces espèces soit l'introduction de l'espèce piscivore. Le processus d'extinction des petites espèces est donc bel et bien enclenché dans le lac Ramsay et il semble rapide. Nous pouvons d'ores et déjà prédire plusieurs autres extinctions au cours des prochaines années si la population de Grands brochets persiste. Chapleau et al. (1997) ont trouvé que les petits lacs du parc de la Gatineau avec piscivores introduits ont moins de la moitié du nombre d'espèces de petite taille que les lacs qui n'ont pas de piscivores. Demers et al. (2001a) ont observé que le nombre d'espèces non piscivores est passé de sept espèces en 1991 à quatre en 1997 suite à l'introduction, dans un petit lac, de deux espèces piscivores, l'Achigan à grande bouche (*Micropterus salmoides*) et l'Achigan à petite bouche (*Micropterus dolomieu*). Findlay et al. (2000) ont montré que le nombre d'espèces de cyprinidés des lacs des Adirondacks était trois fois plus faible dans les lacs ayant des piscivores introduits. Nous pouvons donc prédire que la faune actuelle du lac Ramsay pourrait passer de 12 à quatre ou six petites espèces au cours des prochaines années.

D'ailleurs, les trois espèces disparues appartiennent à la liste des cinq espèces présentes exclusivement dans les lacs sans espèces piscivores du Parc de la Gatineau (Chapleau et al. 1997). Les deux autres espèces de cette liste, l'Umbre de vase (*Umbra limi*), et le Méné laiton (*Hybognatus hankinsoni*) sont donc les prochaines candidates logiques à l'extinction locale. D'ailleurs, cette dernière espèce n'a été capturée que très rarement lors de notre échantillonnage alors qu'elle était abondante en 1991 (Chapleau, observation personnelle). Le fait que les quatre espèces non piscivores les plus abondantes dans le lac en 2001 et 2002 (*Notemigonus chrysoleucas*, *Catostomus commersoni*, *Ameiurus nebulosus* et *Lepomis gibbosus*) sont des espèces de taille intermédiaire démontre qu'il y a eu un changement de l'abondance relative des espèces, et cela en faveur des espèces de taille intermédiaire (Chapleau, observation personnelle).

Demers et al. (2001a) ont démontré, suite à une manipulation des communautés de poissons dans deux petits lacs du sud de l'Ontario, que les stocks de poissons diminuaient fortement (de 32 kg ha^{-1} an^{-1} à 5 kg ha^{-1} an^{-1}) en trois à cinq ans suite à l'introduction de piscivores. Dans un autre lac, ils ont également noté un certain rétablissement des stocks (de 12 kg ha^{-1} an^{-1} à 32 kg ha^{-1} an^{-1}) en trois à cinq ans suite à l'enlèvement d'une partie des prédateurs. Dans ce même lac, ils ont observé que deux espèces saisonnières sont devenues résidentes suite au retrait des Achigans à grande bouche et des Achigans à petite bouche. Il serait donc possible de penser que le prélèvement d'une partie importante de la population de Grands brochets en 1998 et en 2001 ait ralenti le processus d'extinction et ait permis à certaines petites espèces rares de se maintenir.

De plus, en 1991, le lac Hawley, un petit lac (5,1 hectares; 17 espèces; 12 espèces de petite taille) tout juste en aval (moins de 1 km) du lac Ramsay, ne comptait pas d'espèces piscivores. Lors d'un échantillonnage préliminaire en 1998, le Grand brochet a été signalé pour la première fois dans ce lac (Chapleau, observation personnelle). Donc, non seulement le Grand brochet est bien établi dans le lac Ramsay, mais il se répand présentement dans les lacs adjacents.

Croissance du Grand brochet

Les longueurs totales rétrocalculées des individus du lac Ramsay capturés en 1998 et 2001 sont comparables aux moyennes pour les populations du sud du Québec (Vallières et Fortin 1988) (voir figure 3). Les Grands brochets capturés en 1995 ont eu une croissance lente lors de leur première année.

Nous avions prévu une croissance rapide des Grands brochets au lac Ramsay à cause de l'absence d'autres espèces piscivores et de l'abondance de proies. Or, la croissance est normale. Cela peut être attribuables à une compétition intraspécifique plus importante que prévue. En effet, la petite taille du lac a probablement contribué à l'atteinte d'une densité assez élevée de Grands brochets en peu de temps. Nos résultats ne concordent donc pas avec Stocek et al. (1999) qui ont observé une croissance très rapide du Maskinongé (*Esox masquinongy*) suite à son introduction dans les eaux du Nouveau-Brunswick. Stocek et al. (1999) ont postulé que ce taux de croissance était dû à la faible compétition et à l'abondance de proies. Il est fort probable qu'une partie des Grands brochets capturés au lac Ramsay en 1995 soient nés dans un autre lac, ce qui expliquerait la faible longueur totale moyenne pour les individus à un et deux ans.

Dans plusieurs cas, la longueur moyenne rétrocalculée est significativement plus élevée chez les spécimens de Grands brochets capturés en 2001. On peut supposer que le nombre de grands spécimens a diminué de façon importante lors de la pêche particulièrement intensive de 1998. Les survivants à cette pêche qui ont été capturés en 2001 auraient eu une croissance particulièrement importante. Cela peut s'expliquer en partie par une diminution de la compétition intraspécifique causée par la pêche intensive.

Les Grands brochets capturés en 2001 ont un coefficient de condition de 2,93 (Figure 2) ou une croissance allométrique négative, ils sont donc plus petits par rapport à leur longueur que la normale (c'est-à-dire, 3,0). De plus, leur condition semble à la baisse par rapport aux années d'échantillonnage précédentes. Les valeurs pour 1995 et 1998 étaient respectivement de 3,14 et 3,07, soit une croissance allométrique positive, c'est-à-dire que les individus étaient généralement plus gros par rapport à leur longueur que la normale. Pour d'autres populations, les valeurs obtenues se situent habituellement entre 2,86 et 3,27 (Frost et Kipling 1967; Mann 1976). Il est difficile d'expliquer la diminution du coefficient de condition dans le temps pour les Grands brochets du Lac Ramsay. Il est possible que l'abondance des proies montre une diminution dans le temps, la probable extinction de trois espèces en dix ans étant un bon indicateur que la présence du Grand brochet a eu un impact sur la communauté et possiblement sur le recrutement des proies.

Ratio femelles : mâles

Le rapport femelles : mâles des Grands brochets évolue définitivement en faveur des femelles depuis 1995. Il est passé de 1,2 : 1 en 1995, à 5,8 : 1 en 1998, pour finalement atteindre 15 : 1 en 2001. Ces dernières valeurs sont très élevées, mais au moins un autre résultat semblable a été observé. Frost et Kipling (1967) ont obtenu un ratio de 11,6 : 1 avec les Grands brochets capturés à l'âge de quatre ans en 1951 au lac Windermere (données calculées à partir des résultats de Frost et Kipling 1967). Les années précédente et suivante montrent respectivement un ratio de 2,4 : 1 et de 2,9 : 1. Après six ans, le ratio est revenu à 1 : 1. Les auteurs ne mentionnent pas ce débalancement. Dans la littérature, les proportions varient le plus souvent entre 2 : 1 et 1 : 1 (Frost et Kipling 1967 – calculé à partir des données de l'article; Casselman 1975; Mann 1976 – calculé à partir des données de l'article; Massé 1979 dans Vallières et Fortin 1988; Roche et al. 1999). Casselman (1975) a par ailleurs démontré que les proportions femelles: mâles capturés des Grands brochets avaient tendance à varier selon la saison. En été (croissance somatique) et en hiver (développement des gonades), les femelles deviennent plus actives, ce qui les rend plus vulnérables à la prise au filet maillant. Or, chacun de nos échantillonnages a eu lieu vers la fin de l'été et au début de l'automne. La saison d'échantillonnage ne peut donc pas expliquer le ratio en faveur des femelles et l'évolution de ce ratio dans le temps. En septembre et octobre, les rapports femelles: mâles des populations étudiées par Casselman (1975) sont aux alentours de 1 : 1. Notre résultat suggère donc un sérieux débalancement dans la proportion des sexes dont la cause demeure inconnue.

Remerciements

Nous aimerions remercier le Parc de la Gatineau, la Commission de la Capitale Nationale et la Société de la Faune et des Parcs du Québec pour l'attribution des permis de pêche scientifique. Nous remercions également Anne-Marie Phelps, Thevia Belisle, Kevin Moon, Brent Campbell, Mélanie Barbeau, Annie Comtois, Annie-Chantal Guibord, Julie Lepage et Guy Vachon pour leur aide avec l'échantillonnage. Ce projet a pu être complété grâce à un octroi à la découverte du CRSNG à FC.

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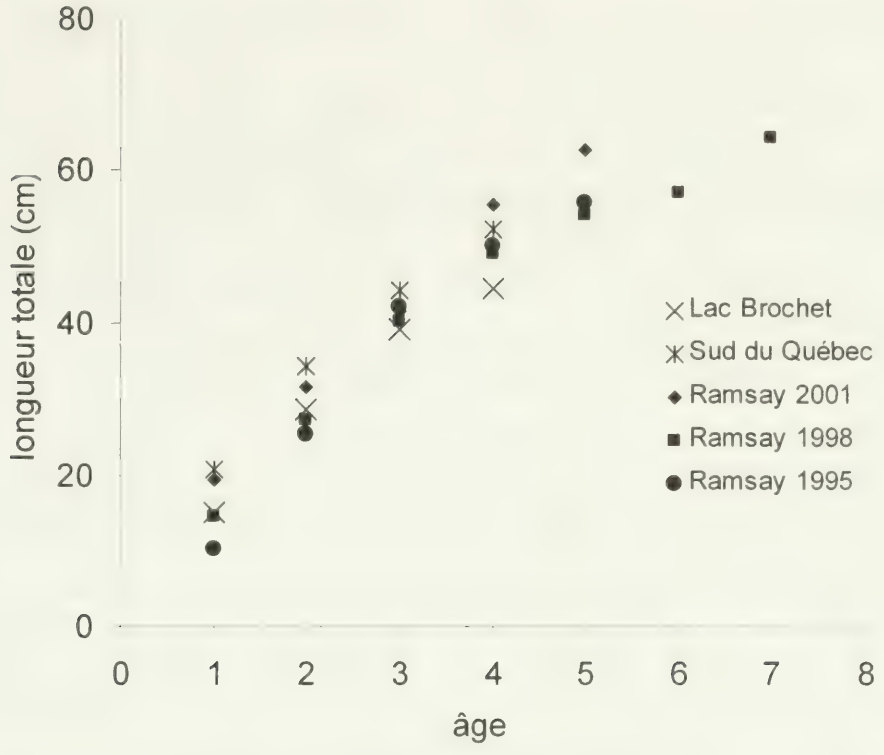

FIGURE 3. Longueur rétrocalculée à chaque âge des Grands brochets de lacs du Sud du Québec (Vallières et Fortin 1988) incluant les données du lac Ramsay pour 1995, 1998 et 2001.

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Reçu le 8 décembre 2003
Accepté le 15 août 2005

Woodpecker Nest Tree Characteristics in Upper Midwestern Oak Forests

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Adkins Giese, Collette L., and Francesca J. Cuthbert. 2005. Woodpecker nest tree characteristics in Upper Midwestern Oak forests. Canadian Field-Naturalist 119(3): 367-376.

Characteristics of woodpecker nest trees have been widely studied in some regions of North America. However, there is little research from the Upper Midwest. Forest managers need information on woodpecker nest tree characteristics so they can recommend leaving during harvest trees that meet the needs of cavity-dwelling wildlife. Information specific to the Upper Midwest is especially important given that declines in several species of cavity nesting birds have been predicted by an environmental analysis of timber harvest in Minnesota. Our purpose was to identify attributes of nest trees used by primary cavity-nesting birds. We compared nest trees to unused trees and examined differences in nest trees among woodpecker species. We found 166 active woodpecker nests in upper midwestern oak forests in 1997 and 1998. For each nest tree, we recorded height, diameter, status, and aspects of tree decay. We also measured four potential nest trees (non-nest trees, within size requirements of cavity-nesting birds, with ≥2 indicators of heartwood decay) closest to each active nest tree. Additionally, we recorded these measurements for 137 randomly selected potential nest trees. Using paired *t*-tests and chi-square analysis, we found each woodpecker species had a unique set of characteristics that separated nest trees from potential nest trees. Using an extension of the McNemar test for related samples, we found woodpeckers as a group used trees that were larger, both in diameter and height, more often elm (*Ulmus americana, U. rubra*) or aspen (*Populus tremuloides, P. grandidentata*), more likely to have old cavities present, and with more decay indicators than adjacent potential nest trees. The Yellow-bellied Sapsucker (*Sphyrapicus varius*) differed from the other woodpecker species by nesting in living Trembling Aspens (*Populus tremuloides*) with intact tops, complete bark cover, and heartwood fungus. Diameters of nest trees differed significantly among woodpecker species, but unlike findings from other studies, the height of nest hole and nest tree did not. Woodpecker nest entrances faced south or southeast significantly more often than by chance alone, even when excluding leaning trees. This study suggests that generic forest management for all woodpecker species may not be adequate because individual species have specific nest tree requirements. Management recommendations for cavity-nesting birds need to be tailored to meet the needs of a diversity of species.

Key Words: Woodpeckers, nest site selection, oak forests, timber management, Minnesota.

Woodpeckers play a key role in forest communities. The unique ability of woodpeckers to excavate holes in trees for nesting and roosting creates habitat for many other species of cavity-dwelling wildlife. Additionally, as predators of forest insects, woodpeckers may help control insect outbreaks (Bruns 1960). These natural history traits should make conservation of this group a priority in forest management. Declines in the numbers of several species [e.g., Barred Owl *(Strix varia),* Boreal Owl (*Aegolius funereus*), Northern Saw-whet Owl (*Aegolius acadicus*), Yellow-bellied Sapsucker *(Sphyrapicus varius),* American Three-toed Woodpecker (*Picoides dorsalis*), Black-backed Woodpecker (*Picoides arcticus),* Pileated Woodpecker *(Dryocopus pileatus),* Great-crested Flycatcher *(Myiarchus crinitus),* Black-capped Chickadee *(Parus atricapillus),* Boreal Chickadee (*Poecile hudsonica*), Redbreasted Nuthatch (*Sitta canadensis*), and White-breasted Nuthatch *(Sitta carolinensis)*] of cavity-nesting birds have been predicted in the Upper Midwest (Generic Environmental Impact Statement on Timber Harvesting in Minnesota 1994, Minnesota Environmental Quality Board, St. Paul.

Without knowledge of specific habitat requirements of cavity-nesting birds, conservation of these species is difficult. Information on woodpecker nest trees has important implications for forest management, including which trees are best to leave for wildlife during harvest and whether general guidelines are suitable for all species.

Only certain trees are suitable for woodpecker excavation. The tree must be large enough to support a nest, but selected tree size depends on woodpecker body size (Conner et al. 1975). In general, trees larger in diameter and height are used more often than smaller trees (Welsch and Howard 1983; Zarnowitz and Manuwal 1985). Woodpeckers also require trees with heartwood decay (Kilham 1971; Conner et al. 1976), which is caused by fungal invasion of the inner wood; decay softens the wood and facilitates excavation. Consequently, woodpeckers often choose dead or dying trees for nest hole excavation. However, some tree species (e.g., *Populus* spp.) can contain suitable heartwood decay while they are still alive (Kilham 1971; Runde and Capen 1987). Woodpeckers are not restricted to certain tree species for nesting. However, some

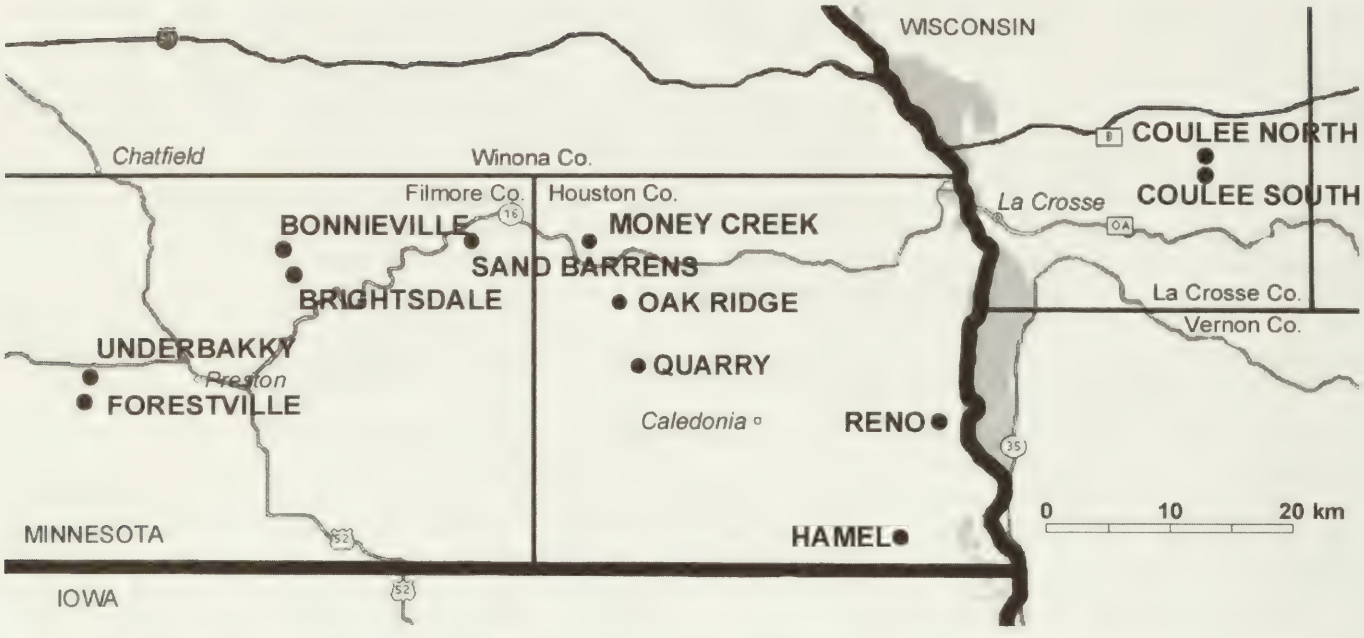

FIGURE 1. Map of Houston and Fillmore counties of Minnesota and La Crosse County of Wisconsin showing locations of 12 woodpecker nest tree study plots in upper midwestern oak forests, 1997-1998.

tree species are preferred substrates for woodpecker nest excavation (Thomas et al. 1979).

The characteristics of nest trees used by woodpeckers have been widely studied in some regions of North America. Research on woodpecker nest site selection in the western United States is most extensive (McClelland and Frissel 1975; Bull and Meslow 1977; Scott 1978; Scott et al. 1978; Mannan et al. 1980; Scott et al. 1980; Scott and Oldemeyer 1983; Winternitz and Cahn 1983; Raphael and White 1984; Zarnowitz and Manuwal 1985; Sedgewick and Knopf 1986, 1990; Li and Martin 1991; Schreiber and deCalesta 1992; Dobkin et al. 1995).

Outside the western U.S., fewer researchers have examined characteristics of nest trees used by woodpeckers. Studies have been done in northern hardwood forests of Vermont, New York, and New Hampshire (Kilham 1971; Swallow et al. 1986; Runde and Capen 1987). Other research was conducted in oak-hickory forests of southwestern Virginia (Conner 1975; Conner et al. 1975, 1976; Conner and Adkisson 1977). Only a few studies focused on the Upper Midwest, including oak-hickory forests of east-central Illinois (Reller 1972) and riparian areas in Iowa (Stauffer and Best 1982).

Because characteristics of snags vary widely among biotic communities (Zeedyk 1983), information from other regions may not be applicable to upper midwestern oak forests. Geographically specific information on nest tree requirements of woodpeckers is needed to develop regional forest management guidelines for cavity-nesting birds.

The objective of our study was to identify attributes of nest trees used by primary cavity-nesting birds (woodpeckers). We address the following questions: (1) Do trees chosen for nesting by woodpeckers differ from unused trees in terms of tree size, tree condition, and tree species? (2) Are there differences among woodpecker species in nest tree size, tree condition, and tree species?

Methods

Study Area

Our study area was located in Houston (43°40'N, 91°30'W) and Fillmore (43°40'N, 92°05'W) counties, southeastern Minnesota, and LaCrosse County (43°19'N, 91°27'W), western Wisconsin, United States (Figure 1). This area was uncovered by the Wisconsin Glaciation and is referred to as the Driftless Area. The pre-settlement vegetation was oak woodland and brushland and maple-basswood forest (Marschner 1974). The landscape has become highly fragmented, consisting primarily of oak forest patches surrounded by agricultural lands.

We selected plots from available state-owned forests (Richard J. Dorer Memorial State Hardwood Forest, Forestville State Park, and Coulee State Experimental Forest) on the basis of accessibility and intensity of public use. The plots were widely scattered: the westernmost and easternmost plots were approximately 90 km apart. We studied 12 plots (8 plots each year; for maps see Adkins Giese 1999). Plots were 28-40 ha (mean = 36 ha).

The study area has a varied disturbance history including logging, grazing, and fire. None of the plots was logged in the last ten years; however, firewood cutting was allowed at one site. Only the Quarry plot, which included some private land, was grazed in the last ten years. Some plots were in forest fragments as small as 40 ha, while others were within more extensive forest tracts.

All plots were in closed-canopy mature forest, ranging in age from 80 to 120 years. The canopies were dominated by oaks (*Quercus rubra*, *Q. alba*, *Q. bicol-*

or) (30 percent of all trees sampled), but also included hickories (*Carya ovata, C. cordiformis*) (13 percent), elms (17 percent), basswood (*Tilia americana*) (8 percent), aspen (6 percent), other hardwoods, and some White Pine (*Pinus strobus*). Young plants of these canopy trees and hazel (*Corylus* spp.), gooseberry (*Ribes* spp.), and raspberry (*Rubus* spp.) made up the woody understory. We provide additional details on habitat structure and composition in another paper (Adkins Giese and Cuthbert 2003), which focuses on the broader habitat needs of woodpeckers. Breeding bird surveys found that the plots had 56 bird species, including 13 cavity-nesting species (M. Friberg, University of Minnesota, personal communication).

We marked the plots with flagging tape, forming a grid used to plot locations of woodpecker activity on field maps, mark nest locations, and specify locations for the randomly selected sites.

Nest Searching

In 1997, we began searching for nests 6 May and stopped 23 June. In 1998, we began searching for nests 20 April and stopped 22 June. After formal nest searching ended, we opportunistically located additional nests during vegetation surveys.

We searched for active nests of all primary cavity-nesting birds on the plots, excluding the Black-capped Chickadee. The primary cavity-nesting birds included Downy (*Picoides pubescens*), Hairy (*P. villosus*), Red-bellied (*Melanerpes carolinus*), Red-headed (*M. erythrocephalus*), and Pileated woodpeckers, Yellow-bellied Sapsuckers, and Northern Flickers (*Colaptes auratus*).

We found nests by following woodpecker vocalizations, drumming, and flight paths. We found additional nests by systematically walking the plots and examining trees with cavities and fresh chips at the base. Our goal was to find as many nests as possible, rather than to make plot comparisons, thus there was no attempt to equalize nest-searching efforts across plots. We included nests found outside plots as long as they were within the study area. We found nests of the Red-headed Woodpecker along roadsides, as well as on the plots.

We considered nests to be active if we observed any of the following: (1) adult completely entering cavity and remaining for over 10 minutes; (2) adult flushed from cavity; (3) adult feeding young; and (4) young calling from cavity. Because of difficulty locating Red-headed Woodpecker nests, an adult repeatedly entering a cavity but not remaining inside was considered sufficient evidence of nest activity.

Vegetation Surveys

We recorded characteristics of all active woodpecker nest trees found. For comparison, we also obtained vegetation measurements for the four closest potential nest trees and a sample of randomly selected potential nest trees. Potential nest trees were defined as non-nest trees, within the height and diameter requirements of cavity-nesting birds, with ≥2 indicators of heartwood decay (Conner 1978). Decay indicators included old cavities, tree scars, branch stubs, fungal conks, and significant dead portions. Potential nest trees were not presently used by woodpeckers, but some had indications of previous use. In accordance with the minimum nest height and tree diameter used by woodpeckers, potential nest trees were >15.2 cm diameter at breast height (dbh) and >1.8 m tall (Thomas et al. 1979). We modified the study methods after Runde and Capen (1987).

We recorded vegetation characteristics to describe tree size, tree condition, and tree species of nest trees and potential nest trees (Table 1). To describe tree size, we recorded tree height and dbh. To describe the tree condition, we recorded tree status, top condition, limb condition, presence of decay indicators, and percentage live wood and bark cover in quartile classes. For consistency, the same person took all subjective vegetation measurements.

To determine the availability of trees of various sizes and species for nesting and to get a sample of randomly selected potential nest trees, we sampled trees in circular subplots (11.3 m radius) randomly distributed across the plots. For all trees within the subplots, we recorded species, status, and size class. From subplots that contained potential nest trees, one potential nest tree was randomly chosen for comparison to nest trees ($n = 137$).

Data Analysis

We compared nest trees to potential nest trees to evaluate woodpecker nest tree selection. Comparisons of nest trees among the woodpecker species were also made to determine interspecific similarities and differences. Alpha levels < 0.05 were used to indicate significance.

We statistically compared size, condition, and species of nest trees to adjacent potential nest trees. By using adjacent potential nest trees, rather than randomly selected potential nest trees, we could assess how the nest tree differed from other trees within the chosen nest area. We used paired *t*-tests to compare dbh and height of nest trees to the mean of four adjacent potential nest trees. Because data for available trees were categorical, with diameter based on size class, we used chi-square to compare the diameter of nest trees to available trees. An extension of the McNemar test for related samples (Miettinen 1968) was used to compare the condition and species of all woodpecker nest trees to the related sample of adjacent potential nest trees. Using the McNemar extension, we established comparisons using 2 or 3 categories for each independent variable.

Because of high skew and small sample size, the extension of the McNemar test could not be used when comparing the condition and species of nest trees to potential nest trees for each individual woodpecker species. Instead, we used chi-square tests of homo-

TABLE 1. Descriptions of vegetation measurements taken for woodpecker nest trees and potential nest trees in upper mid-western oak forests, 1997-1998.

Variable	Categories	Description
Tree status	Alive, Dead, Partly Dead	Partly dead: tree forked with only 1 fork dead or tree with only small remaining living branches (>75% dead)
Tree height	N/A	Measured using a clinometer
Top condition	Top intact, Top broken, Broken fork	Top broken: tree top ends abruptly. Broken fork: trunk split with 1 fork intact and 1 broken
Limb condition	Trunk, Main branches, Secondary branches, Foliage twigs	Smallest type of branches remaining, regardless of whether branches were dead or alive
Percentage live wood	0-25, >25-50, >50-75, >75	A subjective estimate of percentage live wood in quartile classes
Percentage bark cover	0-25, >25-50, >50-75, >75	A subjective estimate of percentage bark cover in quartile classes
Heartwood fungal conks	Presence, Absence	*Formes igniarius,* the shelf fungus of Trembling Aspen, and other large shelf fungi
Sapwood fungus	Presence, Absence	Small, superficial tree fungi
Old cavities	Presence, Absence	Holes that looked as if they were completely excavated by a woodpecker
Trees scars	Presence, Absence	Tree wounds with exposed heartwood (natural cavities, excavation attempts, and deep foraging holes)
Significant dead portions	Presence, Absence	Dead portions large enough to be nesting substrate for Downy Woodpecker (>15 cm diameter; >30 cm long)
Branch stubs	Presence, Absence	Broken branch or stem >15 cm diameter and >30 cm long or broken branch <50 cm on stem >15 cm diameter

geneity to compare nest trees to a randomly selected sample of potential nest trees. Because each independent variable had 2 or 3 categories, we set up 2×2 or 2×3 chi-square contingency tables, accordingly. If we found a significant difference within a 2×3 chi-square contingency table, we broke the table into non-independent 2×2 tables for examination of where non-homogeneity occurred (Brunden 1972).

We also made comparisons among the woodpecker species for nest tree size, condition, and species. We used Kruskal-Wallis ANOVAs to compare the dbh and height of nest trees among the seven species of woodpeckers. When we found a significant difference among species, we used a multiple comparison procedure using rank sums to determine which species differed significantly from each other (Dunn 1964). To compare the condition and species of the nest tree among the species of woodpeckers, we used chi-square tests of homogeneity. The Northern Flicker and the Pileated Woodpecker were not included in comparisons among the woodpecker species because of small sample size.

Results

Comparison of Nest Trees and Unused Trees

We found 166 nests, including 76 in 1997 and 90 in 1998 (Table 2). Woodpecker nest trees had significantly greater diameter and height than adjacent potential nest trees (Table 3). Over 50% of nest trees were 23-38 cm dbh (Figure 2). This diameter class was used out of proportion to its availability ($\chi^2 = 893$, $P < 0.001$, df = 1).

The decay condition of active woodpecker nest trees also differed from potential nest trees. In comparison to adjacent potential nest trees, nest trees of all woodpecker species combined were less likely to have broken tops ($P < 0.05$), were more likely to have foliage-bearing twigs present ($P < 0.01$), were more likely to have heartwood fungus present ($P < 0.01$), were less likely to have significant dead portions present ($P < 0.05$), had more total decay indicators present ($P < 0.001$), and were more often elm or quaking aspen ($P < 0.001$). Nest trees also were more likely to have old cavities present (55% of nest trees versus 4% of potential nest trees), but the high skew invalidated the McNemar extension. These results were highly influenced by the large sample of Yellow-bellied Sapsuckers, which reflected the species' strong preference for living aspens with intact tops and heartwood decay (Table 4). When the Yellow-bellied Sapsucker was excluded, only number of decay indicators ($P < 0.01$) and tree species elm or aspen ($P < 0.001$) remained significant. The percentage of nest trees with old cavities still remained high (51% of nest trees versus 8% of potential nest trees). There was no difference found between nest trees and potential nest trees in tree status, percentage live wood or bark cover, or in the presence of branch stubs or tree scars.

Certain tree species were frequently used for nesting by woodpeckers. Woodpeckers nested in American Elms (*Ulmus americana*) and Trembling (Quaking) Aspens much more often than expected based on availability ($\chi^2 = 391$, $P < 0.001$, df = 1). American Elm and Trembling Aspen provided 70% of all nest sites, but constituted only 10% and 5% of all trees in random plots, respectively. Dead American Elms made up <1% of available trees and dead Slippery Elms (*Ulmus rubra*) made up approximately 1% of available trees.

TABLE 2. Number of nest trees with each characteristic for seven species of woodpecker in upper midwestern oak forests, 1997-1998

	Downy Woodpecker	Hairy Woodpecker	Red-bellied Woodpecker	Red-headed Woodpecker	Yellow-bellied Sapsucker	Pileated Woodpecker	Northern Flicker	All[a]
Sample Size	44	22	29	20	42	4	5	166
Tree Species Used								
Elm	21	8	10	14	3	2	4	62
Trembling Aspen	5	6	5	2	37	1	0	56
Oak	10	3	4	1	2	0	0	20
Paper Birch[b]	1	2	3	0	0	0	0	6
Basswood	1	0	6	0	0	0	0	7
Big-toothed Aspen[c]	0	0	1	2	0	1	0	4
Black Cherry[d]	2	1	0	0	0	0	0	3
Other	4	2	0	1	0	0	1	8
Presence of Decay Indicators								
Branch Stubs	44	22	29	20	42	4	5	166
Heartwood Fungus	7	10	7	2	40	1	0	67
Sapwood Fungus	14	3	8	1	1	0	1	28
Tree Scars	10	8	11	2	8	2	3	44
Old Cavities	18	10	16	14	28	3	5	94
Significant Dead Portion	42	14	29	18	6	3	4	116
% Live Wood								
0-25	36	12	19	18	4	3	4	96
>25-50	0	0	0	0	0	0	0	0
>50-75	0	1	1	0	1	0	0	3
>75-100	8	9	9	2	37	1	1	67
% Bark								
0-25	17	5	9	14	2	2	1	50
>25-50	3	3	1	0	0	0	1	8
>50-75	1	0	0	0	0	1	1	3
>75-100	23	14	19	6	40	1	1	104
Tree Status								
Live	7	8	7	2	37	1	1	63
Dead	35	12	19	18	4	3	4	95
Partly Dead	2	2	3	0	1	0	0	8
Tree Top								
Intact	21	12	7	10	41	2	4	97
Broken Top	12	6	14	4	1	1	0	38
Broken Fork	11	4	8	6	0	1	1	31
Limb Condition								
Trunk	6	2	2	1	0	1	0	12
Main Branches	6	2	4	2	0	0	0	14
Secondary Branches	5	1	2	2	0	0	0	10
Foliage Bearing Twigs	27	17	21	15	42	3	4	129
# of Decay Indicators								
1-2	17	7	10	6	11	1	1	53
3	22	10	7	11	23	1	2	76
4	5	4	12	3	7	2	1	34
5	0	1	0	0	1	0	0	2

[a] Includes nests of all woodpecker species found
[b] *Betula papyrifera*
[c] *Populus grandidentata*
[d] *Prunus serotina*

TABLE 3. Paired comparison of nest trees with mean of four adjacent potential nest trees for seven species of woodpecker in upper midwestern oak forests, 1997-1998.

	Tree Diameter (cm)					Tree Height (m)				
	Diff.[a]	SE	*t*	df		Diff.	SE	*t*	df	
Hairy Woodpecker	-0.8	2.8	-1.0	21	NS	2.8	1.3	2.1	21	*
Downy Woodpecker	-0.7	2.4	-0.8	43	NS[b]	2.6	1.1	2.4	43	*
Yellow-bellied Sapsucker	0.1	1.2	0.5	41	NS	5.2	0.8	6.2	41	***
Red-bellied Woodpecker	10.2	5.4	2.1	28	*	4.3	1.4	3.1	28	**
Red-headed Woodpecker	17.0	4.7	4.5	19	***	6.5	1.3	5.1	19	***
Northern Flicker	31.4	20.6	1.6	3	NS	4.7	1.4	3.4	3	*
Pileated Woodpecker	39.9	19.7	3.4	3	*	9.4	6.2	1.5	3	NS
All woodpecker nests	5.3	1.6	2.3	164	***	4.3	0.5	8.2	164	***

[a] The difference of the means (Diff.) of nest tree and four adjacent potential nest trees (nest tree – adjacent)
[b] NS $P > 0.05$
* $P < 0.05$
** $P < 0.01$
*** $P < 0.001$

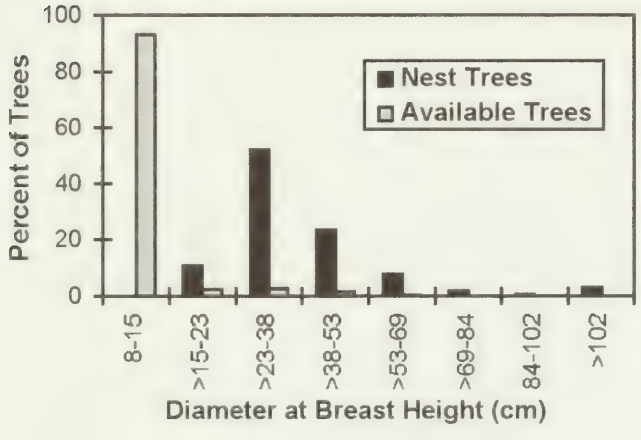

FIGURE 2. Diameter at breast height (cm) in size classes for all woodpecker nest trees and available trees in upper midwestern oak forests, 1997-1998.

Each woodpecker species had a set of characteristics that differentiated its nest trees from randomly selected potential nest trees (Table 4). In comparison with random potential nest trees, nest trees of the Pileated Woodpecker were more often elm or Trembling Aspen ($P < 0.001$), with old cavities ($P < 0.001$), more decay indicators ($P < 0.001$), and less bark cover ($P < 0.01$). Nest trees of the Northern Flicker were more often elm or Trembling Aspen ($P < 0.01$), with old cavities ($P < 0.001$) and more decay indicators ($P < 0.001$).

Comparison Among Woodpecker Species

We wanted to determine if nest tree selection differed among species of woodpeckers. We found a significant difference among woodpecker species in nest tree dbh, but not nest tree height (Table 5). Many differences in nest tree condition among the woodpecker species were found (Table 6). The Yellow-bellied Sapsucker differed from the other woodpecker species by nesting in living Trembling Aspens with intact tops, complete bark cover, and heartwood fungus. No difference among the woodpecker species was found in limb condition, number of decay indicators, and presence of branch stubs, tree scars, and old cavities.

Discussion

Tree Size

Many investigators report that woodpecker nest trees are larger than unused snags (Bull and Meslow 1977; Welsch and Howard 1983; Zarnowitz and Manuwal 1985; Schreiber and deCalesta 1992). We compared nest trees to unused trees that met minimum size requirements. This allowed us to make a comparison with trees that are generally larger in diameter than a random sample of unused snags. We nevertheless found that woodpeckers chose trees that were larger in diameter than adjacent potential nest trees. There are many possible advantages to nesting in larger trees. Larger trees may contain more places to excavate. Larger trees are probably older and therefore more decayed. Additionally, larger trees enable construction of cavities with thicker walls, which provide thermal insulation, protection from predators, and lower probability of breaking at cavity height (Kilham 1971; Miller and Miller 1980).

Ranges of tree diameters used by Downy and Hairy woodpeckers and Yellow-bellied Sapsuckers in our study are comparable to ranges found in the literature (Conner et al. 1975; Evans and Conner 1979; Thomas et al. 1979). However, in our study, 55% of trees used by Red-bellied Woodpeckers and 20% of trees used by Red-headed Woodpeckers were below the observed optimum range of nest tree diameters given for these species (Evans and Conner 1979). Selection may be different for these species in our study area or our sample may not be representative. However, it is possible that our results suggest a shortage in the study area of large diameter trees required by Red-bellied and Red-headed woodpeckers.

TABLE 4. Characteristics that significantly differed (chi-square tests of homogeniety) for seven species of woodpecker in upper midwestern oak forests. 1997-1998.

	% of trees with characteristic	
	Nest trees	Random Potential Nest Tree[a]
Downy Woodpecker (n = 44)		
Dead or partly dead[b*]	84	66
Broken forked top[**] (d.f. = 2)	25	6
Tree elm or Trembling Aspen[***]	59	18
Old cavities present[***]	41	4
Sapwood fungus present[*]	32	11
3 or more decay indicators[***]	61	28
0-25% bark cover[***]	39	9
Hairy Woodpecker (n = 22)		
Tree elm or Trembling Aspen[***]	64	18
Old cavities present[***]	45	4
Heartwood decay fungus present[***]	45	13
Without significant dead portion[***]	36	9
3 or more decay indicators[**]	68	28
Red-bellied Woodpecker (n = 29)		
Tree elm or Trembling Aspen[***]	52	18
Broken forked top[***] (d.f. =2)	28	6
Old cavities present[***]	55	4
3 or more decay indicators[***]	66	28
0-25% bark cover[**]	31	9
Red-headed Woodpecker (n = 20)		
Tree elm or Trembling Aspen[***]	80	18
Dead or partly dead[*]	90	66
Broken fork[**] (d.f. = 2)	30	6
Old cavities present[***]	70	4
3 or more decay indicators[***]	70	28
0-25% bark cover[***]	70	9
Yellow-bellied Sapsucker (n = 42)		
Tree alive[***]	88	34
Top intact[***] (d.f. = 2)	98	62
Tree Trembling Aspen[***]	88	8
Old cavities present[***]	67	4
Heartwood decay fungus present[***]	95	13
No significant dead portion[***]	86	9
3 or more decay indicators[***]	74	28
75-100% bark cover*	95	81

[a] n = 137 random potential nest trees
[b] d.f. = 1 unless otherwise indicated
[*] $P < 0.05$
[**] $P < 0.1$
[***] $P < 0.001$

Generally, woodpeckers with larger body sizes require larger diameter nest trees (Conner et al. 1975). Similar to other studies (Conner et al. 1975; Brawn et al. 1984; Raphael and White 1984; Li and Martin 1991), we found a significant difference among woodpecker species in nest tree diameter, which generally corresponded with woodpecker body size.

Woodpeckers chose nest trees that were taller than adjacent potential nest trees. When taller trees are available, nest heights tend to be higher because higher nests make nest cavities less easily detected and reached by predators (Miller and Miller 1980). A nest located high in the tree gives the woodpecker more time to dislodge or discourage a predator climbing the trunk (Kilham 1971). Other investigators have also found that woodpeckers choose taller trees (Welsch and Howard 1983; Zarnowitz and Manuwal 1985; Sedgewick and Knopf 1990; Joy 2000).

There were no significant differences among woodpecker species in nest tree height or nest hole height in our study. However, other investigators have found differences in nest tree height or nest hole height (Conner et al. 1975; Stauffer and Best 1982; Brawn et al. 1984; Raphael and White 1984). Harestad and Keisker (1989) explained difference in nest tree height among woodpeckers as a consequence of different preferences for tree condition.

Tree Condition

Trees used by woodpeckers had several indicators of heartwood decay. Soft heartwood is a necessity for excavation (Kilham 1971), and tree wounds, such as branch stubs, tree scars, and old cavities, provide access to the heartwood and serve as entry points for fungi. Number of decay indicators present depended in part on the tree species. It appeared that tree species with especially hard wood, like oaks and cherries, required more decay for the wood to become suitably softened for excavation.

Woodpeckers often chose trees with old cavities. Old cavities are clear indicators of past suitability and also serve as entry points for additional heartwood fungi. Return of birds to the same tree is likely also a function of tree availability and territoriality. One active Yellow-bellied Sapsucker nest tree contained 16 old cavities.

Differences in condition of trees chosen for nesting by each species may be explained by differences in the excavation abilities of the species (Spring 1965). Downy Woodpeckers are weak excavators and often choose trees with some sapwood fungi (Harestad and Keisker 1989; this study). Presence of sapwood fungi suggests that the outer wood is soft, making the wood easier to excavate. However, we found trees with extensive sapwood decay were not used for nesting. Such trees may not offer adequate protection of the nest cavity (Kilham 1971; Conner et al. 1976). Yellow-bellied Sapsuckers most often nested in living trees with sound sapwood and several indicators of heartwood decay. *Fomes igniarius*, a heartwood fungus that attacks live wood, especially of Trembling Aspen, softens the heartwood but leaves the sapwood sound (Harestad and Keisker 1989). Nearly all Yellow-bellied Sapsucker nest trees had conks of *Fomes igniarius* present.

Tree Species

American Elms and Trembling Aspens were most frequently used for nesting. Although we found no nests in Slippery Elms, there were more dead Slip-

TABLE 5. Diameter at breast height (dbh) and height of nest trees of seven species of woodpecker upper in upper midwestern oak forests, 1997-1998.

		Nest Tree dbh (cm)				Nest Tree Height (m)			
	n	Mean	SE	Min	Max	Mean	SE	Min	Max
Yellow-bellied Sapsucker	42	30 A	0.80	19	42	20 A	0.62	8	34
Hairy Woodpecker	22	33 A	3.0	20	76	17 A	1.1	8	24
Downy Woodpecker	44	35 AB[a]	1.9	16	63	17 A	0.91	6	29
Pileated Woodpecker	4	69 BC	23	42	127	21 A	5 0	9	29
Northern Flicker	4	69 BC	22	38	121	18 A	2.6	14	23
Red-bellied Woodpecker	29	47 C	5.0	23	137	18 A	1.1	8	29
Red-headed Woodpecker	20	54 C	7.0	28	168	19 A	1.2	7	27
All woodpecker nests	101	39	2.2	16	168	18	0.5	6	34

[a] Means with the same letter were not significantly different ($P > 0.05$) by multiple comparison procedure based on ranks

TABLE 6. Significant differences (chi-square tests) among nest tree characteristics of five species of woodpecker in upper upper midwestern oak forests 1997-1998.

		% of nest trees with each characteristic							
	n	Species Trembling Aspen	Heartwood fungus present	Sapwood fungus present	Significant dead portion	Livewood >75-100%	Bark cover >75-100%	Tree alive	Tree Top intact
Downy Woodpecker	44	11 A[a]	16 A	32 A	95 A	18 A	52 A	16 A	48 A
Red-bellied Woodpecker	29	11 A	24 AC	28 AB	100 A	31 A	66 A	24 A	24 A
Red-headed Woodpecker	20	27 A	10 AC	5 AB	90 AB	10 A	30 A	10 A	50 A
Hairy Woodpecker	22	17 A	45 C	14 AB	64 B	41 A	64 A	36 A	55 A
Yellow-bellied Sapsucker	42	88 B	95 B	2 B	14 C	88 B	95 B	88 B	98 B

[a] Percentages with same letter reflect means that were not significantly different ($P > 0.05$) by multiple comparison.

pery Elms available than dead American Elms. This observation suggests that American Elms have decay characteristics that suit woodpeckers.

The propensity for Yellow-bellied Sapsuckers to nest in aspens has been well documented (Kilham 1971; Thomas et al. 1979; Runde and Capen 1987; Harestad and Keisker 1989). Aspens may be more prone to decay than most other hardwoods. In our study area, it appears that Yellow-bellied Sapsuckers are weak excavators, as suggested by Jackman (1974), so the extensive heartwood decay of mature aspen are suitable.

Red-headed Woodpeckers primarily nested in American Elms, especially large, barkless elms with many broken branches. Dutch elm disease may have benefited Red-headed Woodpeckers by creating highly suitable snags (Jackson 1976). However, the disease widely eliminated American Elm as a major forest species, and in the future, woodpeckers will have few dead elms for nesting. Elms that died from Dutch elm disease are losing suitability for nesting as tree decay becomes extensive; additional dead elms are lost from blow-down and human removal. Red-headed Woodpeckers will need to rely more heavily on other tree species for nesting or face continued decline. Abundance of Red-headed Woodpeckers in Minnesota has been significantly declining since 1966 (Green 1995).

Downy, Hairy, and Red-bellied Woodpeckers showed more variation in tree species chosen. However, caution should be observed before applying these tree species results to other geographic areas because tree species selected for nesting by these species vary by locality, availability, and tree condition (Bull et al. 1980).

Management Implications

It is important that suitable cavity trees are left during timber harvest. The value of such trees extends beyond their importance to woodpeckers. In upper midwestern oak forests, secondary cavity-dwelling wildlife like the Great-crested Flycatcher, Tufted Titmouse (*Baeolophus bicolor*), House Wren (*Troglodytes aedon*), White-breasted Nuthatch, Barred Owl, and Southern Flying Squirrel (*Glaucomys volans*) all use old woodpecker holes for nesting. Studies have shown that lack of suitable nest sites is a limiting factor for many species of cavity-nesting birds (Cunningham et al. 1980; Zarnowitz and Manuwal 1985; Dobkin et al. 1995).

Our study does not address number of trees to leave for wildlife during timber harvest, but it does offer insight into the characteristics of trees. According to our results, emphasis should be placed on retaining trees with sound sapwood that also show signs of heartwood decay (e.g. broken tops). We recommend

retaining living as well as dead trees, but living trees need to be maintained on long rotations to develop suitable decay characteristics for nesting. Indeed, old growth conditions may take >100 years to develop in both oak-hickory forests and aspen forests (Hardin and Evans 1977; Winternitz and Cahn 1983). Because trees with old woodpecker nest cavities are especially important for nesting, trees with old cavities should be retained.

Trees of various size classes should be retained during harvest. It is important that diameters near the mean for each woodpecker species are provided to encourage excavation of normal-sized cavities and reduce death of nestlings due to overcrowding (Kilham 1968; Evans and Connor 1979; Miller and Miller 1980). Small diameter trees may provide foraging substrate, but they should not be considered substitutes for larger diameter cavity trees. If choices need to be made about which trees to retain, the larger diameter and taller trees should be retained.

In our study, certain tree species, especially American Elm and Trembling Aspen, were used more often than others for nesting. However, undue emphasis should not be placed on importance of tree species. Most woodpeckers are restricted to certain tree species for nesting but require certain levels of decay, which vary by tree species.

Our study suggests that generic management for all woodpecker species may not be adequate because individual species have specific nest tree requirements. However, it may be possible to meet a diversity of species needs if forest managers retain many large trees with a range of decay conditions. Although this paper focuses on the suitability of individual trees for woodpecker nesting, we discuss the role of the larger forest context in another paper (Adkins Giese and Cuthbert 2003). More research is needed on longevity of trees left for wildlife during harvest and the long-term impacts of existing forest management practices on wildlife. However, recommendations from this study, if adopted, would enhance conditions for cavity-dwelling wildlife in upper midwestern oak forests.

Acknowledgments

The Minnesota Nongame Wildlife Tax Checkoff and the Reinvest In Minnesota Program, through the Minnesota Department of Natural Resources, Division of Fish and Wildlife, Natural Heritage and Nongame Research Program, provided funding for the fieldwork. Additional support came from Minnesota Forest Resources Council, the Gordon Gullion Scholarship, and Dayton-Wilkie Natural History Fund of Bell Museum of Natural History, Minnesota Agricultural Experiment Station. Partial funding for the project was appropriated for the Minnesota Forest Bird Diversity Initiative by the Minnesota State Legislature from the Environmental Trust Fund as recommended by the Legislative Commission on Minnesota Resources. We thank S. Gale, M. Friberg, and M. Knutson for assistance in the field study. G. Oehlert and C. Bingham provided statistical advice. We thank D. Andersen and G. Niemi for input and assistance with various aspects of the research.

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Received 27 February 2004
Accepted 24 March 2005

Detectability of Non-passerines Using "Pishing" in Eastern Ontario Woodlands

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During spring and summer 1997, non-passerines were surveyed in three woodlots near Arnprior, Ontario, using standard point counts, and standard point counts combined with "pishing" (pishing involves the observer saying the words "pish pish pish pish" in a continuous series of short bursts). Of the 27 non-passerine species detected, 22 were recorded on more days using pishing as opposed to the standard point count method. However, only three of these species were recorded on significantly more days using pishing. Several woodpecker species approached more closely during point counts with pishing, which facilitated identification. In contrast, raptors and some other non-passerines that may have otherwise gone unnoticed were identified as they fled from the pishing sound. Hence, when the overall goal of research is to detect species richness or to gather presence and absence data in woodlands, point counts combined with pishing may increase detectability of some non-passerines.

Key Words: breeding birds, non-passerines, pishing, point counts, woodlands, Arnprior, Ontario.

Birds are surveyed by numerous methods including line transects, territory mapping, mark-recapture, point count, and playback recordings (Bibby et al. 1992). The point count method relies upon the ability of the observer to correctly identify birds using both visual and auditory cues. For most observers, identifying birds by song is more difficult than is visual detection (Faanes and Bystrak 1981). In addition, some species of birds, especially non-passerines, are rarely heard during the breeding season and thus are usually only identified visually or by call-note; e.g., Sharp-shinned Hawk (*Accipiter striatus*). Moreover, songs or calls of some species are practically indistinguishable from others. Many species of woodpeckers, for example, cannot be positively identified by drumming alone because of the high variation in resonance among drumming substrates (Robbins and Stallcup 1981). Numerous species of birds also are excellent mimics. The Blue Jay (*Cyanocitta cristata*) can imitate the call of the Broad-winged Hawk (*Buteo platypterus*). These difficulties, inherent in the aural detection of some bird species, have resulted in other surveying methods being devised that augment detection probability.

Playback recordings of bird songs and calls have been used primarily for augmenting more conventional survey techniques. This method is primarily used for detecting nocturnal non-passerines and other birds that do not normally vocalize by song (Johnson and Brown 1981; Gunn et al. 2000). Playbacks of Red-shouldered Hawks (*Buteo lineatus*) are used during the breeding season to elicit a territorial response from this uncommon species (Badzinski 2003*). Although playbacks often are useful for attracting conspecifics closer to the observer, a better playback method would attract a number of different bird species. Many naturalists, bird photographers, and several researchers have used "pishing" (described by repeating the words "pish pish pish pish pish") to entice various species of birds to approach the observer (e.g., Emlen 1971; Wiedner et al. 1992; Runtz 1995; Porneluzi and Faaborg 1999; Sibley 2002; Prescott 2003*). In addition, several long-term bird monitoring programs such as the Christmas Bird Count and the Ontario Breeding Bird Atlas also permit pishing to be used to gather species distribution data (Ontario Breeding Bird Atlas 2001*). Interestingly, many European bird species appear unresponsive to pishing (Purdy 1998*; BBC 2003*; but see Foppen et al. 2000). Some researchers believe that pishing simulates the sounds of a group of birds mobbing a predator while others believe that it is curiosity alone that attracts the birds to the sounds (Runtz 1995, Zimmer 2000).

There are few studies that quantify the effectiveness of pishing. Lynch (1995) found that aural stimuli using playbacks, owl imitations, and pishing increased number of species detected. However, Lynch did not attempt to distinguish separate effects of the three stimuli tested. Zimmerling and Ankney (2000) found that, on average, 3.6 more passerine species were detected using pishing during spring point counts than point counts without pishing. Pishing has also been shown to be an effective technique for augmenting fall and winter point counts (MacDonald 2003*). Although primarily used for attracting passerines, it has been suggested that some hawks, owls, hummingbirds, and woodpeckers will also respond to pishing (Zimmer 2000; BBC 2003*). To my knowledge, however, there are no data that examine the effectiveness of pishing

with respect to detecting non-passerines during the breeding season.

Therefore, the primary objective of this study was to determine if pishing in conjunction with the standard point count method (hereafter referred to as pishing) would affect the number of non-passerine species detected relative to the standard point count method (hereafter referred to as standard method).

Methods

Study Area

This study was conducted in three woodlots located near Arnprior, Ontario (45°26'N, 76°21'W). The woodlots varied in size (approximately 0.75 km^2, 2 km^2 and 2.25 km^2), but each was a rectangular "island", bordered on the north by the Ottawa River and non-maintained roads, fields, and residential areas on the other sides. A distance of 10 km separated the middle woodlot from woodlots to the west and east. Vegetation was dominated by mature Sugar Maple (*Acer saccharum*) and American Beech (*Fagus grandifolia*) interspersed with White Pine (*Pinus strobus*). Herbaceous plants dominated the understory vegetation. Each woodlot had at least one small marsh within its boundaries; and swamps were also present within the two largest woodlots.

Bird Surveys

Within each woodlot, two transect paths were flagged with plastic tape before surveying began. Each transect was divided into two lines that formed a 90° angle to each other. The first line of the first transect began in the southwest corner of the woodlot and bisected the northern boundary. The second line began 100 m to the east of the final point of the first line and terminated in the southeast corner of the woodlot. The second transect used the same line configuration as the first, but the orientation was reversed such that the first line of the second transect began in the northeast corner of the woodlot and bisected the southern boundary. The second line began 100 m to the west of the final point of the first line and terminated in the northwest corner of the woodlot. Number of points per line varied with size of the woodlot: the smallest woodlot had 11 sampling points spaced >100 m apart, but lines for the two larger woodlots each had 15 sampling points spaced >100 m apart.

Surveys were conducted from 28 April to 1 July 1997 and began at sunrise (05:00 – 06:00 EST). Wind velocity, measured using a hand-held anemometer, and ambient air temperature, measured with a thermometer, were recorded before surveys began and after they were completed on each of the two lines. Surveys were terminated if wind velocity exceeded 17 km/h or if precipitation occurred (Robbins 1981). Results of incomplete surveys were excluded from analysis.

A different protocol was used to survey birds for each line on a given transect. Surveying both lines on the same day using the different protocols controlled for variation in detectability that might have been attributable to change in weather from one day to the next. The first protocol employed standard point count methodology with birds surveyed for four minutes at each point. Birds were counted if they were detected either aurally or visually within or below the forest canopy. Species and sex (whenever possible) were recorded for each individual detected and the mode of detection (visual or aural) that first allowed positive species identification was also recorded. Behaviour of a detected bird towards the observer's presence was documented for each detection.

During the second protocol, a recording of JRZ pishing was played. The recording only included the "pish pish pish pish pish" repertoire and did not include squeaking, squeeling, owl imitations, or other noises. The pishing recording was analyzed using a spectrogram to ensure comparable quality and temporal aspects with JRZ's voice. The volume of the tape player was set before sampling at a volume similar to that of JRZ's voice pishing. At each point, 30-second intervals of playing the pishing recording and listening periods were implemented. The procedure was repeated three more times, with the speaker held 180° in the opposite direction each succeeding time such that birds on opposite sides of the line had equal detection probabilities. In total, two minutes were spent playing the recording and two minutes were spent in silence. Data on bird species were recorded as on the previous line with three minutes allotted for travel between sampling points.

The order of protocols for each line of a transect was reversed every other day of surveying to control for variation in detectability that might be attributable to time of day. Thus, each woodlot was surveyed for two consecutive days before the next woodlot was surveyed. After all woodlots had been surveyed using the first transect (six complete surveys), the second transect was surveyed (six complete surveys). Thus, 12 surveying days were required to survey all three woodlots using both transects. This was repeated two more times for a total of 36 surveys.

Data Analysis

Chi-square analysis (PROC FREQ; SAS Institute 2001) was used to determine if each bird species was detected more often using one of the two survey methods. Only those bird species that were detected on five or more different days via one of the two methods were tested statistically. Birds that were detected between point count locations were excluded from the analysis.

Results and Discussion

Of the 15 non-passerine species wherein sample sizes were sufficiently large to test for statistical significance, three species were detected on significantly more days using pishing as opposed to the standard point count method (Table 1). However, irrespective

of statistical significance, 22 of the 27 non-passerine species detected were recorded on more days using pishing, whereas only three species were observed on more days using the standard method. Because sample sizes were small, and encounters of some species were likely incidental (i.e., shorebirds), these results should be interpreted with caution. For example, shorebirds were unresponsive to pishing and most were detected on the same day and at the same location several hours after a severe thunderstorm presumably halted their migration activities. These results confirm those by MacDonald (2003*) that suggested, in general, that passerine species seemed to approach more closely in response to pishing than did non-passerines, presumably because passerines mob more frequently. Indeed, both Lynch (1995) and Zimmerling and Ankney (2000) detected 19% more species during point counts using pishing than without, but those studies were limited to passerines during the breeding season.

Interestingly, several woodpecker species were detected more often and approached more closely during point counts with pishing. For example, Hairy Woodpeckers (*Picoides villosus*) and Yellow-bellied Sapsuckers (*Sphyrapicus varius*) often approached within 15 m of the point count location when the pishing recording was played. Northern Flickers (*Colaptes auratus*) were detected significantly more often using pishing than during the standard method but this species did not approach the point-count location. Other researchers (e.g., Zimmer 2000) have suggested that woodpeckers are generally responsive to pishing, and therefore, it is not surprising that they have also been shown to mob predators (e.g., Gehlbach and Leverett 1995).

Although pishing increased detectability by inducing some woodpeckers to approach point-count locations more closely, detectability of other species was also increased due to birds fleeing (i.e., taking flight) from the pishing sound. For example, when pishing was used, Red-shouldered Hawks (*Buteo lineatus*) were recorded significantly more often as they flushed from perches. Other raptors, such as American Kestrels (*Falco sparverius*), Cooper's Hawks (*Accipiter cooperii*), and Merlins (*Falco columbarius*) exhibited a similar response. Had these birds not fled from their perches, they might have gone unnoticed. This fleeing reaction by raptors is not surprising. Other studies have demonstrated that, as a result of harassment by mobbing passerines or advertisement of perception of the predator by the mobbers, predators usually leave (e.g., Bildstein 1982). Admittedly, for species that exhibited a flee response to pishing, any recorded, unnatural sound (e.g., clapping hands or shouting) proba-

TABLE 1. Number of days each non-passerine species was detected using the standard point-count method and pishing in Ontario woodlands, 1997.

Common Name (Species name)	Standard	Pishing	P[a]
Canada Goose (*Branta canadensis*)	1	2	nt
Wood Duck (*Aix sponsa*)	7	10	NS
Mallard (*Anas platyrhynchos*)	5	8	NS
Blue-winged Teal (*Anas discors*)	0	1	nt
Ruffed Grouse (*Bonasa umbellus*)	6	5	NS
Great Blue Heron (*Ardea herodias*)	1	8	0.01
Osprey (*Pandion haliaetus*)	1	1	nt
Sharp-shinned Hawk (*Accipiter striatus*)	1	1	nt
Cooper's Hawk (*Accipiter cooperii*)	0	4	nt
Red-shouldered Hawk (*Buteo lineatus*)	6	15	0.02
American Kestrel (*Falco sparverius*)	0	1	nt
Merlin (*Falco columbarius*)	0	2	nt
Killdeer (*Charadrius vociferus*)	5	7	NS
Greater Yellowlegs (*Tringa melanoleuca*)	1	0	nt
Lesser Yellowlegs (*Tringa flavipes*)	0	1	nt
Spotted Sandpiper (*Actitis macularia*)	0	1	nt
Dunlin (*Calidris alpina*)	0	1	nt
Least Sandpiper (*Calidris minutilla*)	0	1	nt
Mourning Dove (*Zenaida macroura*)	10	8	NS
Barred Owl (*Strix varia*)	5	7	NS
Ruby-throated Hummingbird (*Archilochus colubris*)	2	7	NS
Belted Kingfisher (*Ceryle alcyon*)	4	5	NS
Yellow-bellied Sapsucker (*Sphyrapicus varius*)	13	17	NS
Downy Woodpecker (*Picoides pubescens*)	5	5	NS
Hairy Woodpecker (*Picoides villosus*)	9	17	NS
Northern Flicker (*Colaptes auratus*)	18	29	0.01
Pileated Woodpecker (*Dryocopus pileatus*)	7	7	NS

[a] NS = no significant difference; nt = not tested (see text)

bly would have induced the same behaviour. For example, on point counts using pishing, Great Blue Herons (*Ardea herodias*) were frequently detected as they flew from the emergent vegetation around swamps. Because better methods, such as playbacks, can be used to elicit a vocal response in some non-passerines, it is not recommended that pishing be used for the sole purpose of surveying these species. In addition, Zimmerling and Ankney (2000) caution that pishing can confound relative abundance estimates of species that are particularly responsive to pishing. However, when the goal of a study is to detect as many bird species as possible in a woodlot, regardless of taxonomy, or to acquire presence/absence data for specific species, the results of this study suggest that pishing, when combined with standard point count methodology, may increase detectability of many bird species, including non-passerines.

Acknowledgments

I am grateful to Dave Ankney for his guidance and assistance throughout this project. I also thank Doug Tozer and Julie Zimmerling for reviewing earlier drafts of this manuscript. A. J. Erskine and two anonymous reviewers provided invaluable comments that greatly improved this manuscript.

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Received 24 March 2004
Accepted 7 March 2005

Evidence of Range Expansion of Eastern Coyotes, *Canis latrans,* in Labrador

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Chubbs, Tony E., and Frank R. Phillips. 2005. Evidence of range expansion of eastern Coyotes, *Canis latrans,* in Labrador. Canadian Field-Naturalist 119(3): 381-384.

Eastern Coyotes were first documented in central Labrador in 1995 and have recently been recorded in coastal Labrador and at three additional locations in central and western Labrador. Here we document additional records indicating range expansion and the possibility of an established population. We also examine the future management of the species in Labrador and its possible effect on this northern ecosystem.

Key Words: Coyote, *Canis latrans,* range, distribution, management, Labrador.

During the middle of the nineteenth century, Coyotes (*Canis latrans*) expanded their distribution northward and eastward in North America (Nowak 1979; Pekins and Mautz 1988; Thurber and Peterson 1991; Lehman et al. 1991; Parker 1995). Coyotes were first recorded in western Québec in 1944, the Gaspé Peninsula of southeastern Québec in 1974 (Georges 1976; Crête and Desrosiers 1995), insular Newfoundland in 1985 (Larivière and Crête 1993; Parker 1995) and finally into Labrador in 1995 (Chubbs and Phillips 2002). Being adapted to a variety of food items and forest types and tolerant of human settlements has allowed the Coyote to expand its range. Here, we report on additional sightings, provide evidence for an established population and examine the consequences of future management of the species in Labrador and its possible effect on this northern ecosystem.

The large canid and ungulate predator-prey system in Labrador is occupied by Wolves (*Canis lupus*), Caribou (*Rangifer tarandus*) and Moose (*Alces alces*). Black Bears (*Ursus americanus*) are also significant predators of these ungulates. This species complement separates northeastern Canada from most other regions in North America which support Coyote populations, including insular Newfoundland, where Wolves are absent. The expansion of Coyotes in eastern North America has been attributed to the clearing of forests for agriculture and timber that increased prey densities and the elimination of Wolves as major competitors (Larivière and Crête 1993; Parker 1995). Hybridization of Coyotes with Wolves has resulted in eastern Coyotes being larger than western conspecifics (Crête and Desrosiers 1995) and recent information on expanding Coyote populations in eastern Québec also indicates that Coyotes appear to be larger in the eastern portion of their range (Thurber and Peterson 1991; Larivière and Crête 1993; Peterson and Thurber 1993). Their larger size and the availability of White-tailed Deer (*Odocoileus virginianus*) were likely important in the successful colonization of Coyotes throughout northeastern North America (Larivère and Crête 1993). Coyotes prey on Woodland Caribou calves in Québec (Crête and Desrosiers 1995). In insular Newfoundland, Woodland Caribou appear to be the keystone ungulate prey species, which has enabled Coyotes to rapidly colonize much of the island (Wildlife Division, unpublished data). In Labrador, both woodland and migratory Caribou (George River Caribou Herd) may be important seasonal food sources (Chubbs and Phillips 2002). Although the northern forests are recognized as sub-optimal habitat for Coyotes (Tremblay et al. 1998), they may persist at low densities, largely depending on the availability of Snowshoe Hare (*Lepus americanus*), mice and voles (Crête and Desrosiers 1995; Samson and Crête 1997; Patterson et al. 2000; Crête et al. 2001).

Study Area and Methods

Central Labrador lies within the Lake Melville-High Boreal Forest ecoregion and is dominated by Black Spruce (*Picea mariana*) with lesser amounts of Trembling Aspen (*Populus tremuloides*), White Birch (*Betula papyrifera*), Balsam Fir (*Abies balsamea*) and White Spruce (*P. glauca*) in river valleys (Meades 1990*). This region has the most favourable climate in Labrador with mean average daily temperatures ranging from -14 to -18°C in February and 13°C in July. Average annual precipitation is 1100 mm with an average snowfall accumulation of 4 m (Meades 1990*).

Coastal Labrador including Red Bay lies in the Forteau Barrens ecoregion and is primarily barrens vegetated with Labrador Tea (*Ledum groenlandicum*) and Sheep Laurel (*Kalmia angustifolia*) with sparsely forested river valleys (Meades 1990*). This region has a high boreal climate with mean average daily temperatures ranging from –9 to –12.5°C in February and

12°C in July. Average annual precipitation is 1250 mm with an average snowfall accumulation of 3.5 to 4.5 m (Meades 1990*).

We interviewed trappers in remote communities throughout Labrador and fur buyers to assess the occurrence of Coyotes in the annual fur harvests. We also collected three carcasses, one harvested by trappers; the other killed on the highway. Local Conservation Officers reported one sighting near Goose Bay, Labrador. We found no other records of Coyotes harvested in other areas of Labrador.

Results

The first record of a Coyote in Labrador is that of an adult male, caught by a trapper on 14 January 1995, along the Churchill River (53°17'N, 60°15'W) approximately 2 km south east of Happy Valley – Goose Bay (Chubbs and Phillips 2002). This specimen was caught during a period of low trapping effort and which continues in Labrador today (Figure 1, Record I).

Around 20 February 2003, an adult male Coyote was trapped near a landfill site (51°44.30'N, 56°25.00'W) just outside the town of Red Bay (Figure 1, Record IV). The skin (NFM MA-82.1) and skull (NFM MA-82.2) of this specimen were collected and positively identified as an adult male and are currently deposited in the Newfoundland Museum of Natural History, St. John's, Newfoundland and Labrador.

On 19 January 2004 another adult male Coyote was picked up by Conservation Officers along the Trans Labrador Highway (53°02.22'N, 61°17.88'W) approximately 200 m west of Pena's River and 75 km southwest of Goose Bay (Figure 1, Record II). The animal had apparently been killed by a vehicle. The carcass was largely intact although it had been partially scavenged.

On 4 February 2004 on Lake Melville near Rabbit Island (53°23'N, 60°06'W), two Conservation Officers on snowmobiles during daylight hours approached to within 10 m of a Coyote crossing the frozen lake (Figure 1, Record III). The officers, familiar with both Wolves and Coyotes, observed the animal for several minutes and confirmed that it was a Coyote. The Coyote was probably scavenging on fish offal left by ice-fishers in the area.

In early December 2005, an adult male Coyote (M. Pritchett personal communication) was trapped near the landfill size 52°56.07'N, 66°51.24') approximately 3 km east of the town of Wabush in western Labrador (Figure 1, Record V). The whole animal weight on a 50 lb scale was recorded at 45 lb (20.4 kg) and the pelt was graded as XXL at the Northern American Fur Auction (J. Shouse, personal communication).

Discussion

The expansion of Coyotes in Labrador may have been influenced by the recent southern extension of the winter range of the George River Caribou Herd during the last two decades. Caribou of the George River Herd have been recorded as far south as 52°10'N in central regions and 54°00'N near Cartwright along the coast of Labrador. Increased Moose densities in southern Labrador (Chubbs and Schaefer 1997) may provide additional food to support Coyotes through the winter. Coyotes are a highly adaptable species (Pilgrim et al. 1998) and are capable of surviving with a seasonally reduced prey base and harsh weather (Patterson et al. 1999). Coyotes are very efficient scavengers and they may have expanded their range along a coastal route, scavenging on remains of abundant herds of Harp Seals (*Pagophilus groenlandicus*) and the less abundant Ringed (*Pusa hispida*) and Hooded seals (*Crystophora cristata*), and various fish and marine birds. Since 1992 the Trans Labrador Highway has provided an interior travel corridor between eastern Québec, Wasbush, and Goose Bay. More recently a coastal highway from Québec to Red Bay and Cartwright may provide an additional route for Coyotes to reach southeastern Labrador.

The additional records reported here support the possibility of an established population in Labrador, as Coyotes are excellent colonists (Pilgrim et al. 1998) and coexist, thought at low densities, with Wolves in Alaska (Thurber and Peterson 1991), Alberta, British Columbia, Yukon and more recently Idaho (Pilgrim et al. 1998). No geographic barriers exist to discourage Coyotes from extending their range northward into Labrador. Delineation of Coyote range expansion in Labrador may have been delayed due to the absence of systematic surveys for carnivore species and because low fur prices in the last decade decreased trapping effort (only three trapped specimens over a ten-year period). It has been known for some time (Lehman et al. 1991; Pilgrim et al. 1998) that hybridization of Wolf and Coyote genotypes has occurred in Québec due to the rapid northeast progression of Coyotes. More recently it has also been shown that eastern Coyotes share a common evolutionary ancestry with the North American eastern Wolf (Wilson et al. 2000; Wilson et al. 2003). The larger size of eastern Coyotes may have contributed to their success in range expansion into Labrador. Eastern Coyotes make use of snow packed by human activities, especially snowmobile trails, facilitating their travel and dispersal (Crête and Larivière 2003). Coyotes possibly maintain viable populations in northern forests, due to their high adaptability, great mobility, and low trapping effort (Trembley et al. 1998).

Although a breeding record or incidence of an adult female Coyote has not yet been recorded in Labrador, the five records reported here, four of which were adult males, provide evidence of an established population. Labrador's healthy Wolf population may be a controlling mechanism, preventing a rapid population increase that has been observed in insular Newfoundland and elsewhere where Wolves are absent. Wolves are intolerant of Coyotes, killing them where both species overlap, permitting Coyotes to exist at low densities on the edge

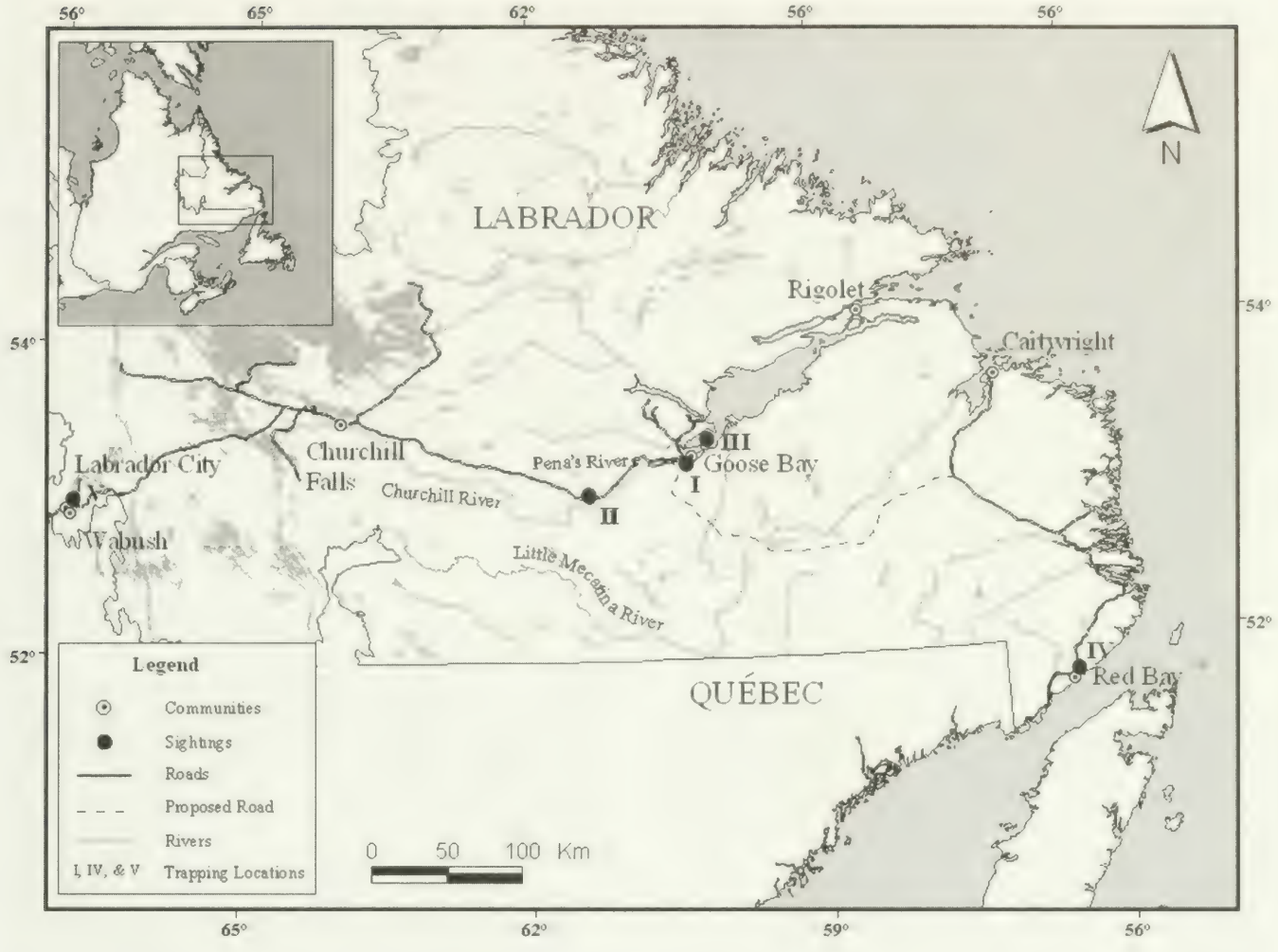

FIGURE 1. Location of Coyote (*Canis latrans*) records in Labrador. Sites I, IV, and V are trapping locations. Site II is the road-killed specimen and Site III is an observation of a live Coyote.

of established Wolf territories or within urban areas where Wolves rarely frequent (Parker 1995).

Management Implications

Since the time of European settlement of North America, Coyotes have been considered a predator that must be controlled. The Coyote reached the island of Newfoundland in 1985 and a trapping season was established in 1986. A trapping season for Coyotes was established in Labrador in 1995 shortly after the first confirmed record of the species in February of that year (Chubbs and Phillips 2002). Both regions allowed hunting in 2002. In areas where Coyotes and Wolves coexist they do so at reduced densities through spatial avoidance and changes in behaviour (Arjo and Pletscher 1999; Switalski 2003). We speculate that although Coyotes may not exist at high densities in Labrador due to the presence of Wolves, they may hinder the recovery of threatened Woodland Caribou populations in the area and we encourage studies to evaluate impacts.

Acknowledgments

Thanks are extended to trapper R. Moores for providing the skull and skin of the Red Bay specimen and details of the capture location. Trapper J. Foote provided details of the speciman caught in Labrador west. We also extend thanks to Conservation Officers W. Lyall for details on the recovery of the road-killed Coyote, H. Yetman and B. Duffett for their observations of the Coyote sighting near Rabbit Island, and M. Pritchett for details of the Labrador west specimen. M. Crête, N. P. P. Simon and G. Parker provided comments on earlier drafts of the manuscript. L. Elson drafted the figure. Funding for this publication was provided through the Department of Natural Resources.

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Received 7 September 2004
Accepted 6 September 2005

Consequences of Beaver, *Castor canadensis*, Flooding on a Small Shore Fen in Southwestern Quebec

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Reddoch, Joyce M., and Allan H. Reddoch. 2005. Consequences of Beaver, *Castor canadensis*, flooding on a small shore fen in southwestern Quebec. Canadian Field-Naturalist 119(3): 385-394.

We describe the changes in a small peatland in Gatineau Park, Quebec, between 1878 and 2004. We correlate these changes with water levels and Beaver activity during this period. A shore fen persisted until 1980 under a regime of relatively stable water levels interspersed with episodes of somewhat higher water that killed encroaching trees. Significantly higher water levels in the early 1980s transformed the fen into a shallow water wetland containing a few partially-floating fragments of the fen. In 2003 a beaver dam collapse lowered the water level dramatically, exposing the peat surface and making it available for colonization by existing aquatic and shoreline communities. If maintaining the fen had been part of the Park's beaver control program, water levels should have been allowed to fluctuate in order to control tree growth but not permitted to rise high enough or for long enough to drown the fen.

Key Words: Beaver, *Castor canadensis*, fen, flooding, floristics, shallow water wetland, shore fen, wetland succession, water levels, Quebec.

The Precambrian uplands of eastern Ontario and western Quebec adjacent to the Ottawa River valley are dotted with many small lakes, a number of which support fens along their shores. Although botanical exploration of the Ottawa area began in the 1860s, there appear to be few published floristic or ecological studies of these fens. A start on describing the calcareous fens within 50 km of the Parliament Buildings in Ottawa was made in the late 1970s (Reddoch 1979, 1984, 1989; Reddoch and Reddoch 1997).

By the end of the 1920s Beaver populations in eastern Canada and elsewhere had declined to low levels because of excessive exploitation. Thereafter, populations began to rise again, partly the result of quotas, trap line restrictions and reintroductions of breeding animals (Banfield 1974; Peterson 1966) and partly because some human activities created new Beaver habitat (Ingle-Sidorowicz 1982). In Quebec, trapping was banned altogether between 1931 and 1941, and among the places where breeding pairs were introduced was Gatineau Park, across the Ottawa River from Ottawa, Ontario. By the end of the 1950s, Beavers were widespread and abundant in the park and adjacent areas, as was evident from the many new Beaver dams and subsequent flooding of low-lying areas. By the late 1970s, a program to control water levels in Beaver ponds was initiated in Gatineau Park in order to ensure public safety and protect man-made structures (National Capital Commission 2004*). Since then, there have been ten aerial surveys to locate and census the population. The most recent survey, in 2002 – 2003, found 283 active colonies, an average of 0.78 colonies per square kilometre (I. Beaudoin-Roy, personal communication). In Gatineau Park, Beavers are present in an area for a year or more and then are absent for another period of time. They seem to move about more during times of high precipitation (M. Leclair, private contractor, personal communication). In northeastern North America, Beavers frequently inhabit peatlands, especially where there is open water. Their flood waters can modify or kill the vegetation on grounded parts of peatlands while having varying effects on those parts of the peatland that are floating (Damman and French 1987; Mitchell and Niering 1993; Muir-Hotaling c. 2001*; Rebertus 1986; Schwintzer and Williams 1974; personal observation).

We have been doing botanical work in Gatineau Park since the late 1960s, concentrating especially on long-term studies of some native orchid colonies (Reddoch and Reddoch 1997). In the spring of 2003 we noticed that the water level of Black Lake suddenly had dropped a metre, exposing an expanse of peat in the southeastern corner of the lake where we had observed a fen in the 1960s and 1970s. We report here the changes in the wetland that we have recorded on a sporadic basis between 1967 and 2004. From literature references, herbarium collections, air photographs and wood samples, we deduce the various stages of this wetland since 1878, a total of 127 years. We correlate these observations with the water levels and Beaver activity during this period and consider what management strategies would have been necessary to preserve the fen habitat.

Study Site

The study site is about 15 km west-northwest of the Parliament Buildings in Ottawa, Ontario, at the edge of Black Lake (45°29'29"N, 75°51'46"W) in Gatineau Park. The park, which is in the Quebec portion of the National Capital Region, is 363 km^2 in

area; it is owned and managed by the National Capital Commission.

The climate of the region is continental, with warm, moist summers and cold, snowy winters. The mean daily maximum and minimum July temperatures at Ottawa are 26.5°C and 15.4°C, while the corresponding January temperatures are -6.1°C and -15.3°C. Mean annual precipitation is 943 mm, of which one quarter falls as snow. Mean precipitation for the month of July is 90.6 mm; the mean frost-free period is 159 days, extending from the beginning of May to early October (Environment Canada 2004*). At Black Lake, 300 m above mean sea level and about 200 m higher than Ottawa, the temperatures are slightly cooler, the precipitation is slightly higher and the mean frost-free period is slightly shorter (Crowe 1984; Environment Canada 2004*).

Black Lake is on King Mountain, part of the Eardley Escarpment that defines the southwestern exposure of the Canadian Shield in this area. The lake is situated in an east-west trough along a fault line between two ridges rising 50–60 m above it. The bedrock is Precambrian diopsidic gneiss interspersed with granite pegmatite (Hogarth 1962, 1970); it is exposed or shallowly covered with glacial till. The lake is surrounded by forests more than 80 years old that are characteristic of the Middle Ottawa Section of the Great Lakes – St. Lawrence Forest Region of which they are a part (Lopoukhine 1974; Rowe 1972). Much of what is now Gatineau Park was logged and subsequently burned over in the 1800s and early 1900s (Mott and Farley-Gill 1981). The north-facing slope to the south, and adjacent eastern slope, are covered predominantly with Eastern Hemlock (*Tsuga canadensis* (L). Carrière) accompanied by a few scattered individuals of Eastern White Pine (*Pinus strobus* L.), Eastern White Cedar (*Thuja occidentalis* L.), Yellow Birch (*Betula alleghaniensis* Britton),White Birch (*B. papyrifera* Marshall) and Red Maple (*Acer rubrum* L.), while the forest on the south-facing slope farther away to the north is mainly deciduous with Sugar Maple (*Acer saccharum* Marshall) and Red Oak (*Quercus rubra* L.) co-dominant.

Black Lake is about 2 ha in area; it is 150 m across and has a maximum depth of about 8 m. Much of the shoreline is bedrock. Measurements made at the 2-m depth in the lake on 19 July 1982 (Éco-recherches Inc. 1983*) were as follows: water temperature 21.5°C, pH 7.1, dissolved oxygen 7.9 ppm, carbon dioxide 6 mg/L, alkalinity 10 mg/L, total phosphates 0.04 mg/L and sulphates 14 mg/L. The only sources of water are rainfall and runoff from the surrounding slopes, which constitutes a catchment area of about 8 ha. The outlet, and consequently the location of the Beaver dam that affects water levels, is in the southwestern corner of the lake. The subject wetland, 0.12 ha in area, is situated in the southeastern corner, adjacent to the north-facing, 50°slope (Figure 1). This slope provides a cool microclimate for the wetland by shading it for much of the year, except in the summer. The ice forms first in this part of the lake in the fall and thaws last here in the spring.

Materials and Methods

Air photos were examined at the National Air Photo Library in Ottawa. Useful images were available for 1925, 1928, 1935, 1938, 1944, 1948, 1951, 1966, 1971, 1988, 1994, 1999, 2001 and 2002. Some photos were not useful because they were taken in the spring, winter or autumn when the sun was low and the north-facing slope cast a heavy shadow that obliterated details of the wetland and the outlet stream. Scales ranged from 1:6000 to 1:16 000.

Our field notes, as well as our photographs taken at various times between 1967 and the present, provided considerable information. Field work in 2003 and 2004 consisted of identifying the flora on the newly exposed expanse of peat and mapping the area with a 100' steel tape and compass. Inaccessible parts of the site were examined with binoculars. Water levels were estimated from the shapes of the lake in the air photos and, in the field, from the positions of the water in relation to the high-water mark on the steep bedrock face adjacent to the wetland.

Information about the historical tree inventory of the fen was obtained from old stumps and fallen logs by wood identification techniques (Hoadley 1990; Panshin and de Zeeuw 1980). Twenty-six wood samples, a few centimetres in size, were collected and determined to genus level or better. The effects of water immersion and decay caused some difficulties in the identifications. Another difficulty arose with *Thuja occidentalis* samples because these trees were the stunted form found in fens that are not considered in most commercial timber identification work. This form is represented by a dead *T. occidentalis* tree we had collected in another Ottawa area fen (Reddoch 1984). When it died, it was 43 years old, 1m tall and 3 cm in maximum diameter. It was identified partly by its remnants of fibrous inner bark. Like some samples from Black Lake, its wood was hard with annual rings as narrow as 0.1 mm. In contrast, a sample of *T. occidentalis* from a stump on the shoreline of Black Lake near the wetland was quite normal with annual rings about 4 mm wide. It was also difficult to distinguish *Betula* from *Alnus* because the set of diagnostic characters sometimes gave conflicting results, likely the consequence of a nutrient-poor habitat. However, in the case of stumps and trunks more than 20 cm in diameter, *Alnus* can be excluded. In some cases *Betula papyrifera* was readily identified by remnants of bark.

Vascular plants collected during this study have been deposited in the herbaria of the Canadian Museum of Nature (CAN) and Agriculture Canada (DAO) in Ottawa. Grasses were identified by S. J. Darbyshire at DAO in accordance with Dore and McNeill (1980). Mosses collected in 1978 were identified by R. R. Ireland and deposited in Canadian Museum of Nature Moss collection (CANM). Vascular plant (except grass-

FIGURE 1. The shore fen at Black Lake as viewed from the slope to the north on 27 July 1971. Photograph by Joyce M. Reddoch.

es) and bryophyte nomenclature follow Newmaster et al. (1998). The principal depositories for local collections, CAN and DAO, were searched for possible previous Black Lake collections by looking for species that are characteristic of peatlands in this area. No additional species were found. The McGill University Herbarium (MTMG) was examined for Ottawa District orchid collections.

Where possible, the terminology used for wetlands is from The Canadian Wetland Classification System (National Wetlands Working Group 1997) and Crum (1988). In particular, shallow water wetlands have "free surface water up to 2 m deep, present for all or most of the year, with less than 25% of the surface water area occluded by standing emergent or woody plants. Submerged or floating aquatic plants usually dominate the vegetation" (National Wetlands Working Group 1997). Fens are "grass-, sedge-, or reed-dominated peatland[s], often with some shrub growth or a scant tree cover, developed under the influence of mineral-rich, aerated water at or near the surface. ..." (Crum 1988).

Results

1878–1889. On 8 July 1878, James Fletcher collected *Pogonia ophioglossoides* (DAO 767100) and *Platanthera clavellata* (Michx.) Luer (DAO 267278, MTMG 47571; *sub Habenaria tridentata* Hook.) in what he described in his Flora Ottawaensis (Fletcher 1893) as "a tiny bog at Black Lake, high on King's [*sic*] Mountain, Chelsea, P.Q." In earlier parts of the same publication (Fletcher 1889a, 1889b) he listed *Solidago uliginosa* Nutt. from a "swamp on King's [*sic*] Mountain" and *Utricularia cornuta* Michx. from "a small swamp at Black Lake Kingsmere". (In his writings and on herbarium labels Fletcher used "swamp" and "bog" interchangeably. Chelsea [now called Old Chelsea] and Kingsmere were nearby hamlets at this time.) It is likely that all four species were recorded from the same locality; these species taken together suggest an open fen habitat.

1925–1938. The air photos taken in 1925 and 1928 show Black Lake surrounded by forest that extended to the water's edge. By contrast, water levels in 1935 and 1938 had risen somewhat and the trees along the northern and northeastern shores were no longer present. A number of fallen trunks were visible in the water where the trees had previously been. (In 2003 the stumps of these trees were once again exposed. All of the trees we sampled were *Betula papyrifera*.). In the southeastern corner of the lake, the triangular area of the wetland was covered with moderately spaced, moderate-size trees, mostly deciduous, except for a wide band along the lake edge that appears to be open fen. The width of the band was calculated from the 1928 air photo to be about 3 m.

1938–1951. From 1938 to 1944 the lake level appears to have dropped somewhat. However, in 1948 the shape of the lake indicates a somewhat higher water level and there appears to be a band of water between the wetland surface and the shore. By 1951 the band had disappeared but the water was still relatively high. Trees were no longer evident in the wetland, but the fen mat remained. There was now a distinct treeless shoreline around the rest of the lake about 10 m wide showing that sometime during this period water levels had been even higher.

1966–1978. In the late 1950s a scenic parkway was built across the northern slope within 50 m of Black Lake. Its embankment encroaches slightly on a small section of the high-water north shore. Its design seems to have allowed for natural drainage into the lake, and any impact on the lake, other than visual, is not evident. The parkway is closed in the winter. The air photos of 1966 and 1971 indicate that the lake had returned to the low levels of the 1920s. A 1966 air photo is the first one to show evidence of Beavers: a lodge in the northwest corner of the lake. Aiken and Gillett (1974) reported the presence of a Beaver dam in 1971. We visited and photographed the fen from time to time during this period and in 1978 made a species list and collected a few specimens. [See Reddoch and Reddoch (1987) for a photograph of the fen in 1978.] The wetland consisted of an open, poor fen mat edged along the lake with a semi-floating shrub margin. The poor fen mat (*Sphagnum* lawn) was dominated by *Sphagnum magellanicum* and supported *Thelypteris palustris*, *Pogonia ophioglossoides*, *Drosera rotundifolia* and *Triadenum virginicum*. Some plants of *Carex cryptolepis* Mack., *Carex* sp., *Juncus brevicaudatus*, *Iris versicolor*, *Cicuta bulbifera*, *Lycopus uniflorus*, *Aster puniceus* L., *Bidens* sp., *Euthamia graminifolia* and *Solidago* sp. were also present. There were scattered shrubs of *Chamaedaphne calyculata*, as well as some saplings of *Alnus incana* ssp. *rugosa* and young trees of *Betula papyrifera* that had grown to a height of 4 m by 1978. A few plants of *Calla palustris* L. grew in water-filled depressions in the mat. A mid-summer paper pH reading of the surface fen water in 1977 was 5.5 The semi-floating mat at the lake/fen interface (shrub fringe) consisted mainly of *Chamaedaphne calyculata*, which was accompanied by the mosses *Sphagnum magellanicum*, *S. teres*, *Calliergon stramineum* (Brid.) Kindb. and *Campylium polygamum* (Schimp. in B.S.G.) C. Jens. The shape of the fen/lake interface was essentially unchanged from that of 1925. There was a narrow aquatic vegetation zone around most of the lake shore but not in front of the fen, presumably because the water was too deep there. *Nuphar variegata* was visually the dominant species. (In 1971 Aiken and Gillett (1974) identified 19 species of aquatic vascular plants around the lake.) In the late 1960s and early 1970s, there were a few plants of the orchid *Platanthera clavellata*, which had been collected by Fletcher in 1878, on the lake shore to the north of the fen, but we did not find any plants in the fen. In 1978 we noticed that the fen had become somewhat wetter than previ-

ously and a stash of deciduous branches along the lake edge of the fen was evidence of Beaver activity.

1983–2002. In 1983 the *Sphagnum* lawn had been replaced by open water dotted with the still-standing dead *Betula papyrifera* trees. Much of the *Chamaedaphne calyculata* shrub fringe and adjacent *Sphagnum* lawn remained intact as a semi-floating band 2–3 m wide, although many of the shrubs were dying. A large Beaver lodge was prominent in the shrub fringe. The water level in 1983 was at least 30 cm above that of 1978, and by 1988 was a metre higher than in the 1970s. An aquatic community similar to that around the rest of the lake and consisting most prominently of *Nuphar variegata*, *Sparganium americanum* and *Carex* sp. became established in the area of the former grounded *Sphagnum* lawn. By 1990 only stubs remained of the *B. papyrifera* trees; the trunks likely had provided building materials for the two additional Beaver lodges that had appeared by that time. The emergent parts of some larger fallen trunks provided sunning places for Painted Turtles (*Chrysemys picta*) and Northern Leopard Frogs (*Rana pipiens*). In 1992 we photographed a Blanding's Turtle (*Emydoidea blandingi*) there, a species that is extremely rare (S1) in Quebec (Société de la faune et des parcs 2004*).

With continuing higher water, the former *Chamaedaphne* fringe became a line of low-lying islands, which can be seen in air photos as an irregular necklace along the line of the former fen margin and at the edge of the underlying peat. Over the years, the islands slowly have continued to fragment and disintegrate. The fragments have moved shoreward away from their original locations, likely the result of buffeting by wave and ice action driven by the prevailing westerly winds. The dominant vegetation on the islands changed from *Chamaedaphne calyculata* to *Carex lasiocarpa*, although the former was still well-represented. In 2002, July and August were hotter than normal and among the driest on record (Environment Canada 2004*). As a result, the water level of the lake dropped about 0.75 m and three islands that were close to the shores, one at the north end and two at the south end, were left beached.

The northern island measured 0.9 m × 1.30 m; the depth of the peat base as it sat compressed by its own weight was about 30 cm. All of the species included in the 1978 description of the *Sphagnum* lawn (above) were present, except for *Cicuta bulbifera*, *Aster puniceus*, the *Solidago* species and *Betula papyrifera*. There was, in addition, one plant each of five other species: *Typha latifolia*, *Carex pseudo-cyperus*, *Viola macloskeyi* ssp. *pallens*, *Lysimachia thyrsifolia* and *Eupatorium perfoliatum*. *Alnus incana* was represented by one seedling 15 cm high. The dominant moss, *Sphagnum magellanicum*, was accompanied by *S. teres* and *Campylium* sp. [See Appendix for complete species list. A close-up photograph of this island with some of its eight flowering stems of *Pogonia ophioglossoides* is shown in St. George (2002).] By contrast, the two peat islands that were stranded on the south shore had a limited number of species, the dominant cover being *Carex* sp., accompanied by a few plants of *Thelypteris palustris* and *Chamaedaphne calyculata*, as well as some *Sphagnum teres*. The dimensions of these two islands were 1.7 m × 2.2 m and 0.85 m × 0.40 m. These three islands at the northern and southern limits of the island chain represent the extremes in the gradient of the plant compositions of the islands. The farther north the islands were situated, the more species they supported.

2003–2004. In late May of 2003, the lake was at its highest level, as was usual after snow melt. Two weeks later the water level had dropped about a metre because the Beaver dam had given way. Great volumes of water had cascaded down the escarpment onto the lowlands 200 m below (M. Leclair, personal communication). Because there were no Beavers in the lake in 2002, the dam had not been kept in good repair. A device had been installed in the dam that year to maintain a relatively constant water level (M. Leclair, personal communication) but apparently was not functioning adequately in the spring of 2003.

As a result of the drop in water level, the remaining islands settled down onto the peat substrate of the former fen. One fragment about a metre square was stranded on top of a large, previously submerged stump and a smaller piece came to rest on a fallen tree trunk. The substrate was relatively homogeneous, unconsolidated peat, with a shallow surface gradient upward from the lake. Throughout the summer the peat remained saturated. The central area was covered with shallow pools, while the inland borders were moist. Overall there was a related gradient of gradually decreasing moisture from the lake edge to the inland shore of the former wetland. The peat surface was dotted with stubs and stumps rooted in the peat and corresponding-sized trunks lying on and in the peat. There were many *Betula papyrifera* stubs of 6–10 cm diameter, as well as a few *Alnus incana* stubs of similar size. Their presence is consistent with our 1978 observations. Also revealed were a number of *B. papyrifera* stumps in the range of 30–45 cm basal diameter and fallen trunks of related diameters, some still retaining their bark. In addition there were a few similarly sized stumps of *Pinus strobus* and *Thuja occidentalis*, and trunks of the former. At one place, 8 m from the shore, we inserted a 1.8 m probe its full length into the peat, encountering increasing resistance but not touching bottom. At another place, two metres from the shore, the probe descended one metre into the peat. In other places, the probe encountered large rocks like those that occur plentifully all along the base of the slope, as well as some softer objects that possibly were previous generations of trunks and stumps, all less than a metre below the surface.

Along the northeastern and northern shores of the lake beyond the wetland, many more large *Betula papyrifera* stumps were exposed by the drop in water level.

They likely were the remains of the trees shown on the air photos lining the lake shore in the 1920s. Their positions indicate that the drop in 2003 brought the water level back almost to the low level of the 1920s.

As the summer progressed, vegetation developed quickly on the exposed peat. Two different but overlapping communities could be distinguished. A *Sparganium–Sagittaria* community was established closer to the lake, around and in shallow ponds where the water table was close to or at the surface (shallow pool zone). A community of moist to wet habitat, mostly weedy species formed on the broad band of saturated to moist peat between the previous zone and the upland shore (upper shore zone). (The Appendix lists the species that were recorded from each zone.) During the summer, the islands stranded in previous years on the north and south shores continued to dry out and disintegrate.

In 2004 the water level continued at the 2003 level. The plant communities of the previous year became increasingly established. Only one new species was found, a few plants of *Aster lanceolatus* Willd. in the upper shore zone. Several additional species that were present in the upper shore zone in 2003 had invaded the northern beached peat island: *Euphrasia stricta*, *Bidens connata*, *Euthamia graminifolia*, *Solidago canadensis* and *Dulichium arundinaceum*. The base of this island was in contact with the lake water in the late summer and fall. All of the peat islands have disintegrated to the extent that they seem unlikely to survive for more than a few years. The Beavers built yet another lodge, this one over a peat island near the north end of the former fen. Thus, since 1978, Beavers have built five lodges around the lake, four on the former fen and one in the northwestern corner of the lake (at a different location from that shown on the 1966 and 1971 air photos). In 2004 two of the lodges showed evidence of occupation, the one that was built this year and the one across the lake. The seasonal variation in water level during these two years of relatively normal rainfall and temperatures was in the range of 20 cm, except for the record 14 cm rainfall from the remnant of Hurricane Frances, which briefly raised the water level by about 24 cm in September 2004.

Discussion

The level of the water in Black Lake appears to have been the most important factor in determining the nature of the wetland over the past century and a quarter, and presumably for much longer. In the 1920s the water level was relatively low. Judging by the presence of large trees along the shores and in the wetland, we deduce that it had been low for many decades. There was an episode of fluctuating higher water levels in the 1930s, 1940s, and early 1950s followed by a return to the former low level. This level was maintained until the end of the 1970s. From the early 1980s to 2003 there was a period of even higher water than before. This second rise in lake level was the work of Beavers, and it may be that Beavers contributed to the high water of the 1930s and 1940s, perhaps in conjunction with other natural causes. The later increase in water level was of the order of one metre and we estimate that the earlier increase at its peak was about half that. In 2003 the water level dropped almost to the low level of the 1920s.

Until the late 1940s, water levels remained low enough to support a peatland consisting of a lacustrine swamp with a band of open fen along the lake edge. The trees of the swamp appear in air photos to have been a moderate size in 1948. This size correlates with the 30–45 cm basal diameter stumps and corresponding trunks of *Betula papyrifera* that were exposed when the water receded in 2003. The few *Pinus strobus* and *Thuja occidentalis* stumps and trunks may be from the same generation of trees as the *B. papyrifera*. The trees that grew in the central part of the wetland show evidence of stunted growth, reflecting the poor growing conditions of the peatland. *Betula papyrifera* is a common colonizer of open sites on a variety of soils, including wetlands (personal observation), and is often found in pure stands (Farrar 1995). Thus it is likely that the presence of *B. papyrifera* trees of an even age is evidence of a previous disturbance in the late nineteenth century.

By 1951 the water evidently had risen high enough and lasted long enough to kill the trees in the swamp, but appears not to have seriously affected the open fen. Over the next decade the water receded to the former low level, perhaps because a newly built Beaver dam was left unattended and consequently deteriorated after the Beavers were trapped out or had moved on. By the 1960s, a new generation of *Betula papyrifera* and *Alnus incana* began to grow in the area of the former swamp, which by then had developed into a *Sphagnum* lawn. The open fen was a semi-floating *Chamaedaphne* shrub fringe between the *Sphagnum* lawn and the lake. The peatland supported more than 18 species of vascular plants in 12 families. Most studies of the impact of higher water levels on peatlands have been made on bogs and have some parallels to the present work. For example, Schwintzer (1979) has described how moderately raised water levels killed the trees in a treed bog in Michigan. The resultant increased light on the bog mat enhanced the development of *Sphagnum* species and *Chamaedaphne*.

Beavers were present in the lake in the 1960s and the impact of their increasingly high dam at the outlet of the lake began to affect the fen in the late 1970s. Because the *Sphagnum* lawn was grounded, rising water killed all of the vegetation, including the trees, within a few years. The area of the drowned fen was replaced by a *Nuphar–Sparganium* shallow water wetland that lasted until the spring of 2003. The shallow water wetland essentially was an extension over the peat substrate of the aquatic zone already present around the other margins of the lake (Aiken and Gillett 1974).

The original shrub fringe stayed afloat as the water rose but fragmented into a line of islands, which have disintegrated over time. Some of the *Chamaedaphne*

shrubs died and *Carex lasiocarpa* became the co-dominant cover, perhaps because there was a change in the water regime. The composition of the vegetation community on the islands also changed to form a gradient from south to north, the southern islands supporting a restricted number of species, while the composition of the northern islands resembled that of the previous *Sphagnum* lawn (see Appendix). The occurrence of this gradient perhaps can be correlated with the amount of sunlight available through the growing season, the southern islands being increasingly more in the shadow of the slope above them. For instance, from 1980 until the present, the heliophilous orchid *Pogonia ophioglossoides* has been present predominantly on the northern islands. Assuming continuity of fen habitat from 1878 to the present, this is the longest recorded colony of orchids in the Ottawa District (Reddoch and Reddoch 1997).

When the water level dropped a metre in the spring of 2003 as a result of the Beaver dam giving way, the peat generated over the years or centuries by fen vegetation lay exposed. For the first time, emergent and other plants in the seed bank were given the opportunity to germinate. The vegetation that became established on the peat in the first summer consisted of essentially two zones: a *Sparganium-Sagittaria* community in the saturated peat and shallow pools closer to the lake, and an upper shore zone of moist to wet habitat species around the inland edge. A total of 39 species in 21 families made up the vegetation communities in the two zones. Four of the 30 species (13%) in the upper shore zone were aliens (see Appendix). That there is spacial separation of species in relation to water level is well known (see, e.g., Odland and del Moral 2002). The species in the two zones are characteristic of these habitats in the Ottawa area. Most of the species in the upper shore zone were also present on the adjacent eastern shore of Black Lake. They included only two of the five most abundant species listed by Le Page and Keddy (1998) as buried seeds in nearby Beaver ponds in Gatineau Park. Of the total of 37 species that LePage and Keddy (1998) discovered in Beaver pond sediments in the park, only 11 species in all were present in the upper shore zone at Black Lake. The shallow pool zone included about eight of the 16 aquatic species that were identified in 1971 by Aitken and Gillett (1974) from the margins of the lake.

As Crum (1988) has pointed out, it is difficult to estimate the rate of peat accumulation. He suggested that peatlands in the area of the upper Great Lakes can take 100 to 900 years to produce 30 cm of peat. Using these numbers, one can deduce that the depth of the peat in the Black Lake wetland, which is at least 1.8 m deep, may have taken between 600 and several thousand years to develop. An accumulation rate consistent with Crum was obtained from a core taken in the Mer Bleue peatland in the Ottawa Valley 30 km to the southeast (Camfield 1969). Unlike the Mer Bleue, the Gatineau Park area where Black Lake is located was not flooded by the Champlain Sea but has been open since the Wisconsin glaciation retreated about 12 000 before present (Romanelli 1975).

Mott and Farley-Gill (1981) state that the almost unchanged forest composition in the Gatineau Park area over the past 3200 years indicates that there have been only minor variations in the climate during that time. The only major changes in the forest composition have occurred since logging began in the area about 175 years ago. It is not known what impact, if any, logging has had on the Black Lake wetland nor whether the trees in the wetland have ever been logged. A few of the larger stumps have flat tops, but the condition of the wood in all of them precludes any definite conclusions. It is possible that any dead trunks still standing in the mid-1960s were cut down at the same time that the adjacent eastern slope was cleared of undergrowth, presumably to improve the view from the newly built parking lot beyond the eastern slope.

It is recognized that Beaver flooding in certain circumstances can increase species richness and landscape diversity. In a forested region such as the Adirondacks, New York, ecosystem engineering by Beavers has introduced wetlands into the landscape (Wright et al. 2002). On the other hand, at Black Lake, Beaver flooding destroyed the shore fen that had made a unique contribution to the biological diversity of Gatineau Park (Gillett and Catling 1983). The fen has been replaced, over the short term at least, by plant species already well represented in the lake's aquatic and shoreline flora. Fens are the product of centuries of development and cannot quickly redevelop.

The provincially extremely rare Blanding's Turtle was present in the shallow water wetland phase at Black Lake in 1994. Since this elusive turtle is known to occur in (and move between) various types of wetlands, including peatlands (Bider and Matte 1996; Cook 1981, 1984; McMurray 1984*; Desroches and Rodrigue 2004), it is not known how the changes in Black Lake over the past several decades have affected its suitability for this species. This turtle is known in the province only from a few reports in southwestern Quebec (McMurray 1984*; Bider and Matte 1996; Desroches and Rodrigue 2004).

Preserving the fen at Black Lake would have required maintaining historic low water levels. Every few decades a short period of higher water (about half a metre higher) would have been required to kill the trees. If the preservation of existing natural communities in Gatineau Park had been a criterion when the objectives for managing Beavers were drawn up, much more careful attention would have had to be given to the impact of changing water levels on these communities.

Acknowledgments

We are grateful to Francis R. Cook, Researcher Emeritus, Canadian Museum of Nature, for information and valuable comments on the Blanding's Turtle in Quebec, as well as confirming our identification of the

Blanding's Turtle that we photographed at Black Lake; to Stephen J. Darbyshire, Biologist, Agriculture and Agri-food Canada, for identifying the grasses; to Robert R. Ireland, former Curator, Canadian Museum of Nature, for identifying the 1978 mosses; and to Donna Naughton, Research Assistant, Research Services, Canadian Museum of Nature, for background papers on Beavers. We thank the following staff of the National Capital Commission, Gatineau Park: Michel Viens, Senior Manager, Natural Resources and Land Development, for a permit to conduct this research in Gatineau Park, and Isabelle Beaudoin-Roy, Biologist, for providing background information and reports, and, in addition, Michel Leclair, contractor for Beaver management in the Park, for information on Beaver activities and management strategies.

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Received 28 October 2004
Accepted 17 August 2005

APPENDIX: VASCULAR PLANTS AND MOSSES OF THE BLACK LAKE WETLAND 2002–2003

Nomenclature (except for grasses) and arrangement follow Newmaster et al. (1998); nomenclature for grasses follows Dore and McNeill (1980). The abundance of each species is ranked on a subjective scale from rare through occasional, frequent and common. An asterisk (*) indicates an alien species (Gillett and White 1978).

1. Partially Floating and Recently Beached Islands: 2002–2003

BRYOPHYTA (Mosses)
Sphagnum magellanicum Brid. — common
Sphagnum teres (Schimp.) Ångstr. in Hartm. — occasional
Campylium sp.— rare

POLYPODIOPHYTA (Ferns)

THELYPTERIDACEAE
Thelypteris palustris Schott — frequent

MAGNOLIOPHYTA (Flowering Plants)

MAGNOLIOPSIDA (Dicotyledons)

BETULACEAE
Alnus incana (L.) Moench ssp. *rugosa* (Du Roi) Clausen — rare, one seedling

GUTTIFERAE
Triadenum virginicum (L.) Raf. — occasional

DROSERACEAE
Drosera rotundifolia L. — rare

VIOLACEAE
Viola macloskeyi F. E. Lloyd ssp. *pallens* (Banks ex DC.) M. Baker — rare

ERICACEAE
Chamaedaphne calyculata (L.) Moench — common

PRIMULACEAE
Lysimachia thyrsiflora L. — rare

LAMIACEAE
Lycopus uniflorus Michx. — rare

ASTERACEAE
Bidens sp. — rare
Eupatorium perfoliatum L. — rare

LILIOPSIDA (Monocotyledons)

CYPERACEAE
Carex lasiocarpa Ehrh. — occasional to common
Carex pseudo-cyperus L. — rare

TYPHACEAE
Typha latifolia L. — rare

IRIDACEAE
Iris versicolor L. — occasional

ORCHIDACEAE
Pogonia ophioglossoides (L.) Juss. — occasional in 2002; rare in 2003

2. Peaty Shore 2003

MAGNOLIOPHYTA (Flowering Plants)

MAGNOLIOPSIDA (Dicotyledons)

NYMPHAEACEAE
Nuphar variegata Durand in Clinton — occasional, shallow pool zone; remnant, non-flowering plants

POLYGONACEAE
**Polygonum persicaria* L. — rare, upper shore zone

GUTTIFERAE
Hypericum mutilum L. — frequent, upper shore zone
Triadenum virginicum (L.) Raf. — occasional, upper shore zone

VIOLACEAE
Viola macloskeyi F. E. Lloyd ssp. *pallens* (Banks ex DC.) M. Baker — occasional, upper shore zone

ROSACEAE
Fragaria virginiana Miller — occasional, upper shore zone
Potentilla norvegica L. — occasional, upper shore zone
**Potentilla recta* L. — rare, upper shore zone

ONAGRACEAE
Epilobium ciliatum Raf. — rare, upper shore zone
Epilobium coloratum Biehler — rare, upper shore zone

BALSAMINACEAE
Impatiens capensis Meerb. — frequent, upper shore zone

APIACEAE
Cicuta bulbifera L. — rare, upper shore zone
Hydrocotyle americana L. — rare, upper shore zone

LAMIACEAE
Lycopus uniflorus Michx. — occasional, upper shore zone
Scutellaria galericulata L. — rare, upper shore zone; common on unused beaver lodge

PLANTAGINACEAE
**Plantago major* L. — occasional, upper shore zone

SCROPHULARIACEAE
**Euphrasia stricta* D. Wolff ex Lehm. — occasional, upper shore zone

CAMPANULACEAE
Lobelia inflata L. — occasional, upper shore zone

RUBIACEAE
Galium tinctorium L. — occasional, upper shore zone

ASTERACEAE
Bidens cernua L. — frequent, upper shore zone
Bidens connata Muhl. ex Willd. — occasional, upper shore zone
Erigeron philadelphicus L. — rare, upper shore zone
Eupatorium maculatum L. — occasional, upper shore zone
Eupatorium perfoliatum L. — occasional, upper shore zone
Euthamia graminifolia (L.) Nutt.—occasional, upper shore zone
Solidago canadensis L. — rare, upper shore zone

LILIOPSIDA (Monocotyledons)

ALISMATACEAE
Sagittaria latifolia Willd. — frequent, shallow pool zone

POTOMAGETONACEAE
Potamogeton epihydrus Raf. — rare, shallow pool zone

JUNCACEAE
Juncus brevicaudatus (Engelm.) Fern. — frequent, shallow pool zone
Juncus canadensis J. Gay ex Laharpe — frequent, shallow pool zone

CYPERACEAE
Carex bebbii (L. H. Bailey) Olney ex Fern. — frequent, upper shore zone
Carex pseudo-cyperus L. — rare, upper shore zone
Dulichium arundinaceum (L.) Britton — frequent, shallow pool zone
Eleocharis obtusa (Willd.) Schult. — rare, shallow pool zone
Eleocharis sp.
Scirpus cyperinus (L.) Kunth — rare, upper shore zone

POACEAE
Agrostis scabra Willd. — frequent, upper shore zone
Torreyochloa pallida (Torr.) Church var. *fernaldii* (A. S. Hitchc.) Dore — rare?, upper shore zone

SPARGANIACEAE
Sparganium americanum Nutt. — common, shallow pool zone

TYPHACEAE
Typha latifolia L. — occasional, shallow pool zone, lake edge

IRIDACEAE
Iris versicolor L. — occasional, upper shore zone

Long-eared Owls, *Asio otus:* A Review of North American Banding

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Houston, C. Stuart. 2005. Long-eared Owls, *Asio otus:* A review of North American banding. Canadian Field-Naturalist 119(3): 395-402.

In Saskatchewan, at the northern edge of the species' range, the Long-eared Owl (*Asio otus*) is an irruptive species that has appeared in numbers during major vole (*Microtus*) outbreaks in 4 of 44 years. Seven other years have had either no bandings or no sightings over large areas. In a search for possible evidence of food-based nomadism, population trends, length and synchronicity of cycles, and longevity, I reviewed all banding in North America through 1998. Prior to banding office computerization (retroactive to 1955), 803 Long-eared Owls had been banded with 33 band encounters (4.1%). Between 1955 and 1998 there were another 10 250 banded by 426 banders with 86 band encounters (0.8%). Encounter records, especially those involving unexpected directions and distances, tend to support but do not prove food-based nomadism. Peaks of migration movements at different long-term stations occurred in different years. There is soft evidence of both 10- and 3-yr cycles. There is inconclusive evidence for a continuing population decline. The oldest banded bird in North America lived for 11 years, 1 month, but another possibly lived for 15 years, 8 months.

Key Words: Long-eared Owl, *Asio otus,* nomadism, irruption, *Microtus,* Short-eared Owl, *Asio flammeus,* Northern Harrier, *Circus cyaneus,* Saskatchewan.

In Saskatchewan, the Long-eared Owl, *Asio otus*, shows extreme variations in numbers, common only during obvious but unmeasured increases in vole (*Microtus* sp.) numbers. In other years, none may be seen across substantial areas.

Are Long-eared Owls nomadic in North America as they are in Europe? (Korpimäki and Norrdahl 1991). If so, how far do they travel in search of voles in high vole years? The subsequent year, when voles are low and the owls virtually disappear from favoured Saskatchewan habitat, where have the owls gone?

The first of four long flights by banded owls in unexpected directions in North America was reported in 1939 (Lincoln 1939); do these represent atypical flights, unusual dispersal, or true nomadism? If nomadic, do peaks occur in different years in different regions? Are Long-eared Owl populations cyclic, and if so, are they on a circa 10-yr cycle that roughly parallels Snowshoe Hares (*Lepus americanus*) and Great Horned Owls (*Bubo virginianus*) (Houston 1987) or on a circa 4-yr cycle with small rodents, as occurs in Europe? Because this is a secretive owl, might single individuals or nonbreeding pairs be present but overlooked during low years? Are North American populations of the Long-eared Owl steady or declining?

I hoped North American banding data might shed light on some of these questions, as well as on longevity of this species. In particular, would banding records show recoveries in subsequent breeding seasons at a distance from the natal site?

Methods

The Bird Banding Laboratory of the U.S. Geological Survey, which maintains data for the North American Banding Program, provided computerized lists with details of all bandings and all reported band encounters since 1955. Numbers of Long-eared Owls banded each year, 1920-1954, were obtained by perusal of all issues of *Bird Banding Notes* (Fish and Wildlife Service 1922-1965*), yielding 802 Long-eared Owls banded before computerization in 1955. Most early bandings were of nestlings, although a specific code for flightless young, age code "04, local," was not designated by the banding office until the August 1949 issue of *Bird Banding Notes*.

(Three 1930s bandings in Alberta were changed from age code "2" to the later designation of age code "4" in Table 2). Another 10 250 Long-eared Owls were banded by 426 different banders after 1955 (Table 1, Figure 1). Of these, 920 were of unknown age, 3499 were locals, 2075 were immatures, 3293 were adults, 230 were SY (second year), 231 ASY (after second year), one TY (third year) and 1 ATY (after third year). Of the 3499 locals banded, Idaho led with 706, followed by Saskatchewan (699), Alberta (361) and Montana (317).

Because of the intense concentration of Saskatchewan banding in five different years, I paid special attention to the Saskatchewan subset and the relations of their numbers to obvious vole peaks. At large migration stations, banding effort, year to year, of all ages of owls, was more consistent than elsewhere, including 1938 banded in Minnesota (1783 by David Evans at Duluth) and 1261 in Michigan (772 at Whitefish Point under four different permits).

Results

Band encounters: where and how found

Pre-1955 banding resulted in 33 band encounters (4.1%). An Alberta subset of 69 nestlings and seven

TABLE 1. Long-eared Owl banding by state and province

All-age Recoveries pre-1955	post-1955	Banded Locals	Banded Total	State or Province	Main banders (>80%) of locals
	6	706	976	Idaho	Marks 285; Ulmschneider 227
1	8	698	705	Saskatchewan	Houston 539; Gehlert 76
8	1	361	399	Alberta	Fyfe 160; Gehlert 19
	4	317	864	Montana	D Holt 285
	2	284	296	Oregon	PWRC #124
1	3	217	301	California	Bloom 175
	2	151	178	Colorado	Ward 85
	1	145	158	Washington	
3	12	84	734	Wisconsin	
		75	90	British Columbia	
		69	96	Utah	
3	14	53	1261	Michigan	
	9	51	605	New Jersey	
		36	65	Arizona	
	3	30	46	North Dakota	
5	8	29	586	Ontario	
2		27	43	Pennsylvania	
	11	26	1938	Minnesota	
		26	27	Nevada	
2	3	21	519	New York	
		11	29	Iowa	
		11	15	Virginia	
2		10	15	Manitoba	
	1	10	37	Nebraska	
		9	16	Kansas	
		8	37	Nova Scotia	
		7	50	Ohio	
		7	21	Quebec	
		6	19	Connecticut	
2	2	4	18	Massachusetts	
		3	9	Maryland	
		3	8	Vermont	
		2	48	Illinois	
		1	6	Indiana	
		1	1	New Brunswick	
		0	1	Atlantic Ocean	
		0	5	Maine	
		0	8	Missouri	
		0	3	New Mexico	
		0	4	Oklahoma	
		0	1	South Carolina	
		0	8	Texas	
		0	4	Wyoming	
	86	3499	10250	Banded after 1955	
33			802	Banded 1920-1954	
	119		11052	GRAND TOTAL 34 STATES, 8 PROVINCES AND ATLANTIC OCEAN	

*Patuxent Wildlife Research Center

Note: 57% of locals banded by 8 of 172 banding permits

None banded in Delaware, District of Columbia, New Hampshire, North Carolina, Rhode Island, Kentucky, South Dakota, or in far south

adult females banded from 1930 to 1937 by W. Ray Salt of Rosebud, Alberta, resulted in a remarkably high six recoveries (7.9%). After 1955, there were only 89 band encounters throughout North America (0.9%).

Of 119 band encounters from the two periods combined, 53 were found dead, 23 shot (12 pre-1955 and 11 post-1955), 8 killed by a car or on a highway, 5 were injured; 18 other encounters fitted into 11 other coded categories, including 4 re-trapped in the same block of latitude and longitude in a subsequent year, 4 netted or re-trapped in an adjacent block, and 4 re-trapped in a distant ten-minute block of latitude from where banded. Details of the latter four travelers are: a bird of unknown age but probably a nestling, banded on

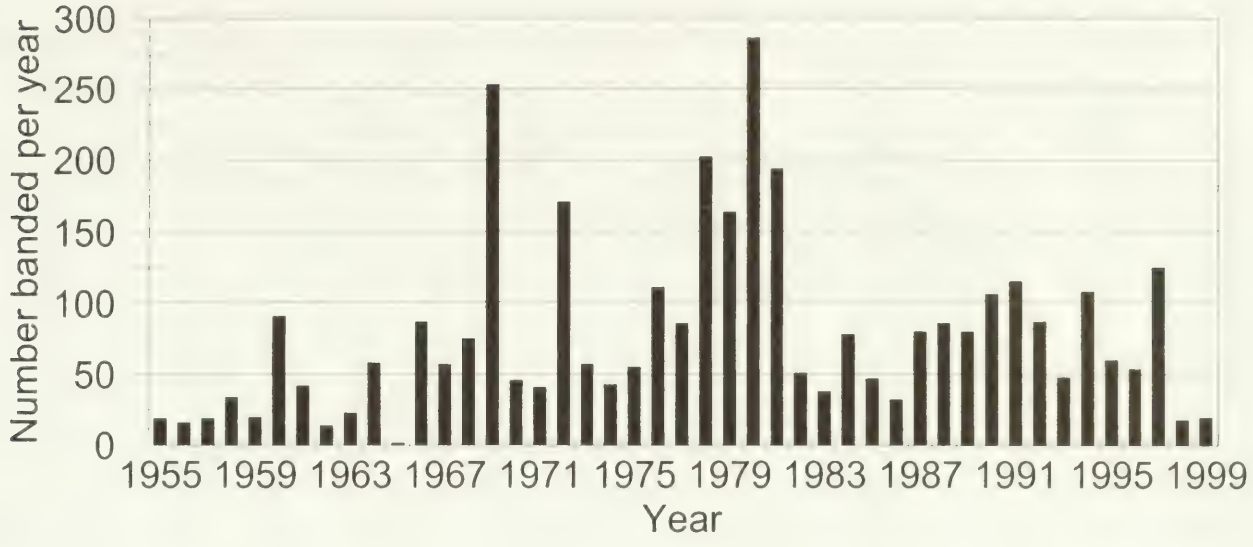

FIGURE 1. Numbers of Long-eared Owls banded each year in North America, 1955-1999.

TABLE 2. Long-eared Owl recoveries banded anywhere in North America.

	Recovery Data								Banding Data							
Band #	Distance (km)	Mo	Dy	Year	How	State/ Prov.	Lat	Long	A	S	State/ Prov.	Lat	Long	Mo	Dy	Year
000556933	175	5	42	1932	89*	AB	524	1120	0	5	AB	511	1125	6	25	1931
053526629	225	11	99	1959	0	IL	414	890	0	0	WI	433	875	10	17	1959
060617751	245	11	30	1969	4	IL	420	895	0	0	WI	433	874	10	25	1969
057690565	400	1	22	1990	0	NY	410	735	0	0	ON	435	765	9	22	1989
000208816	480	4	19	1933	3	NJ	405	735	0	0	MA	412	707	0	0	1927
055674536	590	1	6	1959	15	MD	390	755	0	0	ON	434	791	11	8	1958
060684563	690	1	2	1967	1	NC	362	794	0	0	ON	423	802	4	20	1965
003661927	730	2	42	1936	89*	VA	373	785	0	0	MI	424	841	4	27	1932
002573140	870	12	6	1936	1	NE	420	962	0	0	MB	495	970	7	3	1936
068604234	1035	9	10	1980	14	QU	480	665	0	0	ON	435	785	10	8	1978
003661987	3135	10	9	1934	1	ON	465	843	0	0	CA	330	1170	4	22	1934
081606045	3175	3	24	1977	1	PU	184	975	0	0	MN	465	920	9	20	1973
068600215	140	5	25	1976	45	MI	455	861	1	0	MI	464	845	4	15	1976
036714113	260	5	8	1940	98	ND	465	1020	1	5	ND	484	1020	5	22	1937
040512026	270	4	5	1944	1	WA	482	1181	1	4	WA	463	1203	6	18	1943
088610415	365	4	1	1998	45	IL	402	885	1	0	WI	433	874	11	3	1989
220604277	370	9	2	1994	0	ON	485	880	1	0	MN	465	920	10	19	1993
081611315	370	8	5	1978	0	ON	462	800	1	0	MI	464	845	4	23	1977
081611772	385	12	4	1982	0	WI	455	894	1	0	MI	464	845	4	17	1981
220600812	410	9	3	1994	50	ON	453	814	1	0	NY	431	774	4	7	1991
081623324	470	7	30	1981	0	ON	451	791	1	0	MI	464	845	5	5	1979
056695514	480	6	42	1968	1	QU	484	791	1	0	MI	464	845	5	20	1966
068600211	480	5	2	1975	57	WI	453	905	1	0	MI	464	845	4	22	1975
052624634	500	6	10	1962	0	ON	480	793	1	0	ON	433	792	2	5	1954
056695534	585	1	99	1969	98	WI	435	911	1	0	MI	464	845	5	2	1968
081698373	690	11	18	1988	0	MN	462	935	1	0	MI	464	845	5	1	1988
220615419	825	9	5	1991	0	UT	400	1122	1	0	MT	472	1140	7	17	1990
081625890	1000	4	17	1988	0	QU	465	714	1	0	MI	464	845	5	10	1985
074546503	1430	1	11	1983	0	MS	341	885	1	0	MI	464	845	4	28	1981
081693230	3270	5	20	1990	2	GU	200	1004	1	0	MT	472	1140	6	1	1989
038620218	145	11	63	1939	0	IL	420	881	2	0	WI	430	892	5	15	1939
081620711	145	3	29	1979	0	MN	454	925	2	0	MN	465	920	9	26	1978
081620719	225	10	28	1978	1	WI	450	905	2	0	MN	465	920	9	27	1978
081641608	240	3	29	1984	45	WI	450	902	2	0	MN	465	920	10	18	1981
068600523	355	1	24	1972	3	IL	413	881	2	0	WI	444	875	11	7	1971
220604294	375	3	28	1995	0	MN	444	954	2	0	MN	465	920	10	23	1993

TABLE 2. Long-eared Owl recoveries banded anywhere in North America *(continued from previous page)*

	Recovery Data								Banding Data							
Band #	Distance (km)	Mo	Dy	Year	How	State/ Prov.	Lat	Long	A	S	State/ Prov.	Lat	Long	Mo	Dy	Year
081620719	225	10	28	1978	1	WI	450	905	2	0	MN	465	920	9	27	1978
081641608	240	3	29	1984	45	WI	450	902	2	0	MN	465	920	10	18	1981
068600523	355	1	24	1972	3	IL	413	881	2	0	WI	444	875	11	7	1971
220604294	375	3	28	1995	0	MN	444	954	2	0	MN	465	920	10	23	1993
081604937	440	4	29	1976	89*	MI	464	845	2	0	WI	432	875	10	15	1974
081620400	875	7	12	1978	45	MB	520	1011	2	0	MN	465	920	11	4	1976
074575003	890	1	41	1992	0	IN	403	863	2	0	ON	482	885	9	29	1991
081653319	1260	10	28	1992	0	NB	474	650	2	0	NJ	385	745	11	19	1988
081620108	1305	12	1	1978	0	AR	351	935	2	0	MN	465	920	10	11	1975
036714117	205	8	21	1937	1	SK	502	1043	3	0	ND	484	1020	6	9	1937
000226052	290	11	21	1925	1	IN	413	873	3	0	MI	424	842	5	19	1925
039669347	330	6	28	1942	0	OH	412	814	3	0	PA	404	775	5	16	1941
037642104	615	11	28	1938	1	SD	432	995	3	0	ND	484	1020	6	16	1938
004616735	845	9	4	1933	47	QU	483	770	3	0	MI	430	843	5	14	1933
038687566	1400	12	5	1943	0	TX	332	994	3	0	WI	430	892	5	15	1939
220616638	255	9	41	1994	0	MT	443	1122	4	0	MT	463	1140	5	7	1991
057692535	280	10	8	1968	0	NY	424	734	4	0	NJ	402	750	5	25	1968
057689020	435	6	28	1969	4	MB	505	1005	4	0	SK	520	1065	6	15	1967
057688448	715	2	10	1967	3	MT	454	1083	4	0	SK	520	1064	6	9	1966
057692533	995	10	4	1969	1	NB	473	672	4	0	NJ	402	745	5	20	1968
004629600	1135	2	2	1935	1	UT	410	1115	4	0	AB	511	1125	7	4	1933
057688480	1415	4	9	1969	0	IA	425	935	4	0	SK	520	1070	6	20	1966
004629579	1440	3	3	1934	98	NE	425	981	4	0	AB	511	1125	7	4	1933
050643309	1605	4	1	1961	1	AB	524	1133	4	0	CO	393	1045	6	2	1959
003664770	1660	10	21	1933	98	MN	442	930	4	0	AB	511	1125	6	25	1933
057689017	2365	12	99	1972	0	MS	341	903	4	0	SK	520	1064	6	15	1967
057695906	2385	11	3	1957	1	NL	263	1001	4	0	MI	433	840	5	17	1957
056681737	2825	8	64	1972	98	NL	254	1001	4	0	SK	510	1022	6	20	1967
057612231	3710	1	25	1970	1	DF	191	990	4	0	SK	520	1064	6	13	1969
052622635	3865	99	99	1960	0	OA	163	964	4	0	SK	510	1020	6	15	1960
081611823	465	4	41	1997	0	MI	421	831	5	4	NY	431	774	4	20	1996
074597414	645	7	5	1999	0	ON	463	842	6	0	NY	431	774	4	5	1989

In column 6, how found codes are: 0, found dead; 1, shot; 2, injured; 3, starved; 4, caught in trap; 14, struck by vehicle; 15, killed by weather; 45, killed on highway; 47, band removed; 50, skeleton only; 57, entangled in fence; 89, trapped and released in different 10-minute block; 98, band only without information.

In column F. all bird codes indicate death, except for 89*

In columns 7 and 12, standard postal abbreviations for states and provinces are used.

Additional abbreviations for Mexican states in column 7 are:

DF – Federal District; GU – Guanajuoto; NL – Nuevo Leon; OA – Oaxaca; PU – Puebla; QU – Queretaro

17 April 1932 by P. F. English in Michigan, was re-trapped during mid-February 1936 in Virginia, 730 km distant; an immature banded in Wisconsin by C. R. Sindelar on 15 October 1974 was re-trapped on 29 April 1976 in Michigan, 440 km distant; an owl of unknown age, banded at Nature Dunes Nature Center, Wisconsin, 9 November 1981, was re-trapped on 30 November 1982, 130 km distant in Wisconsin; a nestling banded at Rosebud, Alberta, by Ray Salt on 25 June 1931, was re-trapped 175 km north and west near Killam, Alberta, in mid-May 1932. All but the Alberta owl were probably in migration when banded.

The map (Figure 2) and Table 2 together depict the movements of 64 owls that traveled more than 100 km. Fifteen of the 64 were banded as nestlings, and traveled greater distances, an average of 1672 km, than owls banded at other ages. One wandered north 280 km from New Jersey, in the months after it was banded. Another two were shot after "wrong-way-Corrigan" northward movements of 1605 and 995 km, respectively: from near Denver, Colorado, banded by J. A. Neff on 2 June 1959, to Ponoka, Alberta on 1 April 1961, and from near Stockton, New Jersey, banded by O. A. Heck on 20 May 1968, to Saint Quentin, New Brunswick on 4 October 1969. The other 12 nestlings traveled in a southerly direction, 4 reaching Mexico along with 3 of other ages. Once could speculate that the seven recoveries in Mexico might represent "leap-

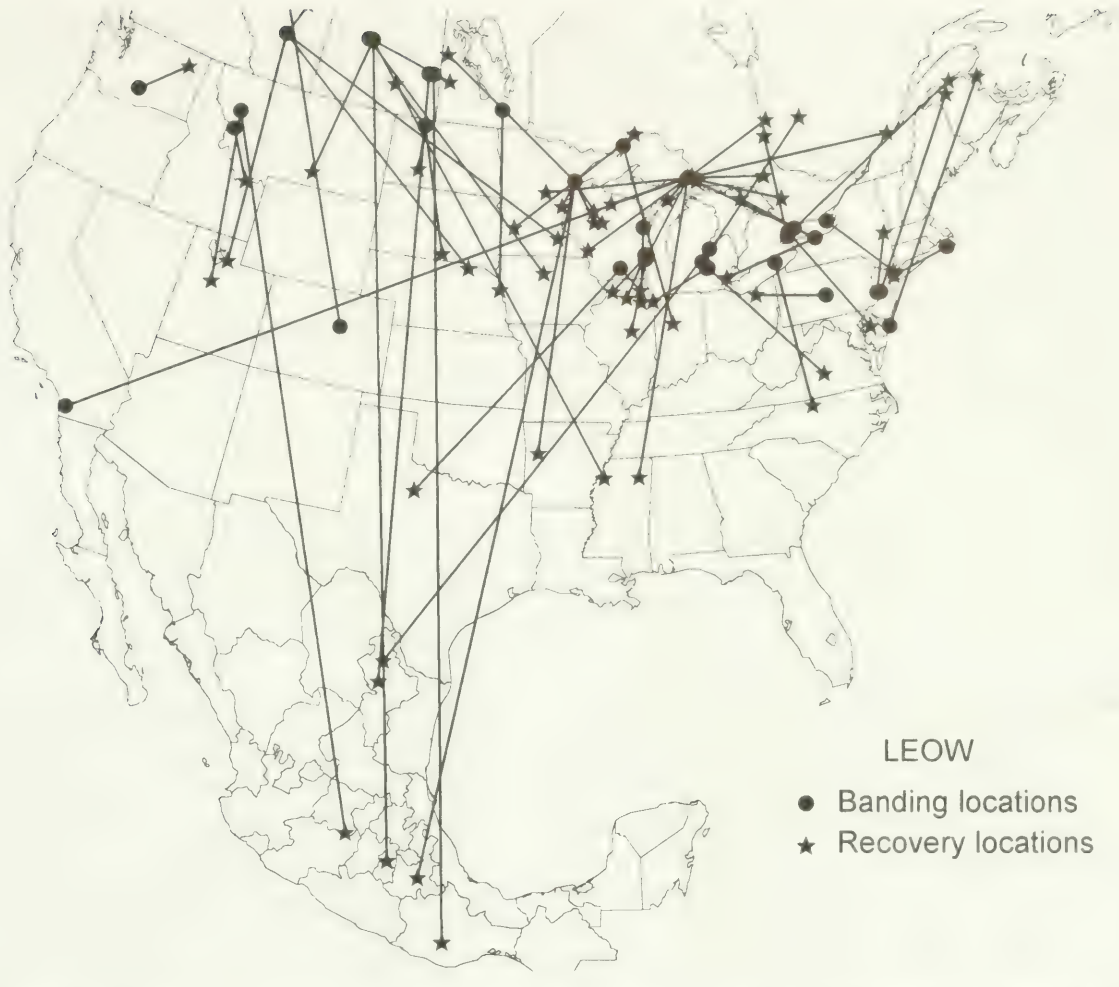

FIGURE 2. Map of Long-eared Owl movements in North America, 1925-1999. Circles represent place of banding. Stars represent place of recovery. Map by K. M. Meeres.

frogging" of northern owls to more southern wintering grounds.

There are four other examples of dispersal in an unusual direction and distance. The first two, presumed to be young in their first year of life, were each recovered in the year of banding. Lincoln (1939: 128) listed a Long-eared Owl of unknown age banded at Escondido, California, 22 April 1934, and shot at Corbeil, Ontario, 9 October 1934, a distance of 3135 km northeast. Considering banding *of all species*, Lincoln commented "This is one of the most unusual records thus far obtained." Lincoln also listed a juvenile Long-eared Owl that had traveled northeast from St. John, Michigan, to Abitibi, Quebec, between 14 May and 4 September 1933, a distance of 845 km. In each of these instances it is not known whether the northward movement was achieved in the first or second year of life, nor whether either represents migratory movement or dispersal to a very different breeding location.

Four distant recoveries during or immediately after the breeding season might have been construed as evidence in favor of nomadism, had they not been banded during migration.

Two were adults banded as April migrants at Braddock Bay, New York; one flew 465 km to the west to Michigan in mid-April of the subsequent year and the other was found dead 645 km northwest in Ontario on 5 July, 10 years after it had been netted as an SY bird by subpermittee Frank Nicoletti (see below under Longevity). Two others, banded as late migrants at Whitefish Point, Michigan (on 22 April and 14 May), were recovered two years later; one went northeast 480 km and was shot in mid-June in western Quebec; the other went southeast 470 km and was found dead on 30 July in Ontario.

Longevity

After deleting ten birds inadmissible because they were alive when recaptured (most of them taken in a net at a banding station and released), two bands found on a skeleton, and two reported as "band only," 105 records remained that were acceptable for a life table (Table 2). As with other raptor species, nearly two-thirds of the band encounters, 67 of 105, occurred before the birds were a year old, with 17 in the second year (Table 3).

The Long-eared Owl accepted by the banding office as their oldest to date was banded as a second-year bird at Braddock Bay, New York, by Frank Nicoletti on 5 April 1989, and found dead in Ontario on 5 July 1999, as already mentioned. At least a year old when banded,

assuming hatching near the first of June, it was at least 11 years, 1 month old, recognized as the longevity record for this species (Klimkiewicz 2005*). A potentially older Long-eared Owl is also in the banding records. Number 816-06355, banded as a nestling near Lincoln, Nebraska, on 24 May 1978 by Ross Lock, was reported as killed by a hawk or owl on an unknown date in February 1994, in the same ten-minute block of latitude and longitude in which it had been banded. Long-eared Owls regularly winter that far north. The unusual and precise mode of death tends to suggest that the band had not been lying in a desk for months or years before it was reported. Had this owl indeed died in February 1994, it would be the oldest Long-eared Owl in North America, at 15 years, 8 or 9 months. Older birds are expected in future, since in Europe, the longevity record for this species is 27 years, 9 months (Rydzewski, cited in Marks et al. 1994).

TABLE 3. Long-eared Owl life table.

Age	Number
+0>1	67
1–2	17
2–3	8
3–4	4
4–5	2
5–6	2
6–7	1
7–8	0
8–9	2
9–10	0
10–11	1
15–16	1
Total	105

119 band encounters 10 inadmissible, because alive when recaptured; 4 excluded, because skeleton (code how found, 50) or 98 (band only), after one year. 105 records available for life table.

Relation to vole numbers in Saskatchewan

In Saskatchewan, between 1969 and 1997, only in three years (1970, 1982, and 1986) were no Long-eared Owl nests detected anywhere in extensive travels throughout west-central Saskatchewan (CSH, personal observation). Also in 1982, and in three other years (1976, 1979, and 1981), no birder in the 11 012 km^2 Saskatoon area reported seeing a single Long-eared Owl at any time (Leighton et al. 2002: 182-183).

The three peak vole years (1960, 1969 and 1997) made a striking contrast. Each occurred in a spring following the rare occurrence of grain crops that were incompletely harvested before snowfall. Some grain crops lay in the swath unharvested all winter, and voles multiplied in the grain beneath the snow. Greatly increased numbers of breeding Long-eared Owls appeared in each of the following springs, together with increased numbers of Short-eared Owls (*Asio flammeus*) and Northern Harriers (*Circus cyaneus*). In 1960, there was a striking increase in the numbers of breeding pairs of Long-eared Owls (73 nestlings banded), Short-eared Owls (68 nestlings) and Northern Harriers (25 nestlings). In 1960, productivity of the Great Horned Owl peaked in concert that year with the ten-year peak of the Snowshoe Hare (Houston 1960).

In the spring of 1969, banders capitalized on a recurrence of high vole numbers to band 195 Long-eared Owl nestlings, 104 Short-eared Owl nestlings and 202 Northern Harrier nestlings (Houston 1997). Long-eared Owl sightings by members of the Saskatoon Nature Society also peaked dramatically in 1969, reaching levels four to ten times higher than any year before or since (Figure 1 *in* Houston 1997).

Although not as widely spread as in 1959 and 1968, occasional fields of grain lay unharvested at first snowfall in the fall of 1996. In the subsequent spring, 1997, voles were common, based on direct observation and anecdotal reports. Some days on Highway 6 south of Regina, voles crossed the highway in such numbers that vehicles left a patchwork of dead voles on the asphalt surface. The three mouse-eating raptors that year showed only modest increases in banding of nestling Long-eared Owls (18), Short-eared Owls (15), and Northern Harriers (23). Fifteen of these Long-eared Owls were on the Marten J. Stoffel (MJS) dairy farm raptor study area immediately north of Saskatoon, a rectangle 8 km east to west and 13 km north to south. Here MJS had found no nesting Long-eared Owls in 1998, one pair with four young in 1999, and an unprecedented density of 36 pairs of breeding Long-eared Owls, one pair per 2.9 km^2, in 2000 (Stoffel 2001).

Are irruptions synchronous?

Unlike Great Horned Owls, whose 10-year cycle tends to be roughly synchronous across much of North America (Houston 1987), peak years for Long-eared Owls appeared to vary widely between localities. At Duluth, D. L. Evans banded 172 Long-eareds in 1978 and 163 in 1981, and mist-netted more than 100 during migration in three other years, 1980, 1986 and 1990. At Whitefish Point, Michigan, the overwhelming peak year was 1981. At Cedar Grove, Wisconsin, the peak year was 1982, whereas Erdman's station near Oconto, Wisconsin, had peak numbers in 1977. At Camden, New Jersey, the peak year was 1988, and at Braddock Bay, New York, the peak years were 1993 and 1994.

How pronounced are cycles?

A casual glance at Figure 1 offers only weak support for a ten-year cycle. However, analysis by James R. Duncan (Manitoba Natural Resources, personal communication) showed 14 minor peaks and hence 13 between-peak-periods (BPP). He found four "2-yr BPPs," 5 "3-yr BPPs," and four "4-yr BPPs." Thus, the mean and coincidentally, the mode BPP was 3

years. Further, Evans' Figure 6, in Marks et al. 1994, shows a four-year cycle of incomplete molt.

Numbers banded at migration stations, where annual effort is more consistent than in itinerant travels to locate nests containing young, showed a continuing decline in Long-eared Owls captured. Apart from banding, there is also suggestive evidence for declines in California, Indiana, Maryland, Minnesota, New Jersey, Pennsylvania, and South Dakota, but not for western Montana (Holt 1997). This suggestion of a gradual decline, even better documented for Short-eared Owls from Breeding Bird Survey data, is somewhat at odds with the locally high numbers seen in Saskatchewan in 2000.

Discussion

Long-eared Owl numbers in Saskatchewan fluctuate in relation to vole numbers; during seven years these owls virtually disappeared from major portions of the province. This was not the case in western Montana or southwestern Idaho, where they were found year-round, including winter, every year, especially in sheltered valleys. On Denver Holt's study area north of Missoula, Long-eared Owls were present and banded every year since 1987, although there was some fluctuation in numbers and in 2 of 15 years (1993 and 1995) he banded no nestlings. In southwestern Idaho, Helen Ulmschneider (1993, 1994) and John Doremus banded young in successful nests for 12 consecutive years, 1988 through 1999.

What might explain the differences between Saskatoon, Saskatchewan (52°N), where Long-eared Owls do not winter, and Holt's study area (47°N) in Montana? Because both Saskatchewan and Montana have adequate numbers of corvid nests, nest sites are not a limiting factor. Even in extreme southwestern Saskatchewan where there are sheltered wooded valleys, Long-eared Owls rarely remain through Christmas week. In contrast, large winter roosts are encountered in Idaho and Montana and at least some owls from the winter roosts remain to nest (Ulmschneider 1993, 1994; D. W. Holt, personal communication). Owls occupy pastoral inter-mountain valleys in Montana whereas the Saskatoon area is largely a cultivated, wind-swept plain with pastures for dairy cattle and scattered copses of aspen (*Populus* sp.).

Because vole cycles are known to be more pronounced in northern Fennoscandia than farther south in Europe (Korpimäki and Norrdahl 1991), and Long-eared Owls winter farther north in Finland in years of vole abundance (Korpimäki 1994), it is possible that vole fluctuations are more extreme in southern Saskatchewan than in Montana, although I know of no Saskatchewan mammal trapping data to support such an hypothesis. In Finland, there is no time lag between population fluctuations of vole-eating raptors and their prey (Korpimäki 1994).

When Long-eared Owl numbers peaked at or near the top of the ten-year Snowshoe Hare cycle in 1960 and 1969, Great Horned Owls had ample hares to feed their young. In such years, Great Horned Owls had less need to take voles, and perhaps competed less often with Long-eared Owls for that prey base.

What have I learned from this review? Clearly, Long-eared Owls and Short-eared Owls increase when voles increase, and thus are owl equivalents of the Northern Harrier, which Fran Hamerstrom (1986) termed "the hawk that is ruled by a mouse." Apart from its clear relationship to vole numbers, other answers are as yet incomplete:

1. Are Long-eared Owls nomadic? Movements of individual banded Long-eared Owls offer tantalizing clues rather than strong evidence in support of nomadism, at least in the northern portions of the range. Full proof of nomadism requires that marked birds that bred in one area be sighted or captured while breeding in another area at a considerable distance. The Northern Saw-whet Owl, for example, appears to settle to breed in areas of high food abundance that it encounters during the nonbreeding season (Marks and Doremus 2000).
2. Are peaks synchronized? No. Numbers of Long-eared Owls peak in different years at different migration stations.
3. Length of cycle? There is "soft" evidence for both three- and ten-year cycles.
4. Is there an overall, continuing population decline? Not proven. Evidence from migration stations, especially at Duluth, 1976-1993 (Evans' figure 5 in Marks et al. 1994), suggests yes; Evans (personal communication) informs me that the average of 90 per year banded at his station, 1974-1993, dropped to 31 for 1991-2003. The evident concentrations that appeared in Saskatchewan in three different years do not exclude a long-term, general downward trend in population.

As Marks et al. said in 1994, similar questions "can be answered only by intensive banding and recapture efforts over many years." Here is an opportunity for all banders to band both nestlings and adults whenever possible. Application of readily visible wing tags or satellite radiotelemetry, should funds and miniaturization permit, might prove invaluable. All of us have a great deal yet to learn about this enigmatic and perplexing species.

Acknowledgments

I thank Gary Bortolotti, Elizabeth Brooks, Tom Carpenter, Jim Duncan, Dave Evans, Denver Holt, Jeff Marks, Bob Nero, Frank Roy, Marten J. Stoffel, and Dan Zazelenchuk for helpful comments. Elizabeth Brooks, David Evans, and Denver Holt gave permission to use their banding data, as did Michael

Kochert on behalf of his subpermittees, Jeff Marks, Helen Ulmschneider, and John Doremus. Mary Gustafson provided the number of individuals banded by W. Ray Salt in Alberta in the 1930s. James R. Duncan analysed the data for determination of cycle length. Kathy Meeres prepared the map. Ross A. Lock and his successor, John Dinan, at Nebraska Game and Parks, kindly followed up on the 15-year-old recovery record.

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Received 17 December 2004
Accepted 1 September 2005

Cyclopyxis acmodonta n. sp. and *Arcella formosa* n. sp.: Two New Species of Testate Rhizopods (Arcellinida, Protozoa) from Remnant Wetlands in Ontario, Canada

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Nicholls, Kenneth H. 2005. *Cyclopyxis acmodonta* n. sp. and *Arcella formosa* n. sp.: two new species of testate rhizopods (Arcellinida, Protozoa) from remnant wetlands in Ontario, Canada. Canadian Field-Naturalist 119(3): 403-411.

Species of the testate rhizopod genera *Arcella* and *Cyclopyxis* are found predominantly in the benthos of shallow ponds, forest pools, marshes and other freshwater habitats. Their taxonomy is based on the morphology of their tests — the shell-like structure that houses the living single-celled amoeboid protoplast. This paper describes a new species of *Cyclopyxis* discovered in two coniferous forest bogs, and a new species of *Arcella* from a *Typha*-dominated marsh on the north shore of Lake Ontario, Canada. *Cyclopyxis acmodonta* Nicholls n. sp. differs from its closest relative *C. stellata* (Wailes) Deflandre 1929 in its much smaller size and its irregularly shaped pseudostomal aperture, which is embellished with numerous, tiny, sharp-pointed tooth-like quartz granules around the interior margin. Although the saucer-like indentations over the dorsal surface of the test of *A. formosa* Nicholls, Meisterfeld & Török n. sp. resemble similar structures found in several other *Arcella* species, the large size of *A. formosa* (165-235 µm in diameter) and its low profile (low height-to-diameter ratio) are the main features distinguishing this new species from other *Arcella* species.

Key Words: *Arcella*, Arcellaceans, Arcellidae, amoebae, *Cyclopyxis*, Testacealobosia, Rhizopoda, Trigonopyxidae.

The species-level taxonomy of most testate rhizopods has been based on the size and shape of their shells or tests – the structure that "houses" the amoeboid protoplast. Species of the testate amoebae genera *Arcella* and *Cyclopyxis* occupy similar habitats (generally shallow benthic freshwaters, bogs, forest pools and damp mosses) and possess certain superficial similarities in their test structure relating to the usual dome-shaped radial symmetry, including a centrally located pseudostomal aperture. Test composition in these two genera is, however, very different and this fact has been the basis for their separate placement in two distinct families. Tests of *Arcella* (family Arcellidae) are of a rigid and transparent organic material, while those of *Cyclopyxis* (family Trigonopyxidae) are composed of mineral particles embedded in an organic cement (Meisterfeld 2002). There are presently about 120 and 80 species and subspecies of *Arcella* and *Cyclopyxis*, respectively.

Deflandre (1928) provided a monographic treatment of the genus *Arcella* that was followed by a similar compilation for the genus *Centropyxis* (Deflandre 1929). In his treatment of the genus *Centropyxis*, Deflandre (1929) erected the subgenus *Cyclopyxis* to include those *Centropyxis*-like tests with radial symmetry (*Centropyxis* tests are bilaterally symmetric). Virtually all authors since then have considered *Cyclopyxis* an autonomous genus quite distinct from *Centropyxis*. *Arcella* and *Cyclopyxis* taxonomy has been summarily updated by Decloitre (1976, 1977, 1979, 1982 and 1986). Unfortunately, many taxa, especially at the subspecies level, were originally poorly described on the basis of very few specimens, so little is known of the range of form variation and how this relates to the morphology of similar but differently named taxa. Based on a detailed study of form variation of tests, Foissner and Korganova (1995) suggested that nine species and subspecies of *Cyclopyxis* might be reduced to two valid species. Since Decloitre's latest taxonomic update (Decloitre 1986), descriptions of new taxa of *Arcella* and *Cyclopyxis* have been few (e.g., Chardez et al. 1987; Torres and Jebram 1993; Balík 1995).

The purpose of this paper is to describe one new species in each of the genera *Arcella* and *Cyclopyxis* discovered recently in wetlands in Ontario, Canada. Features of test morphology of both species are highly distinctive and not easily confused with previously known taxa. Detailed statistics on test dimensions, as well as light microscopic digital images and drawings, are included.

Methods

Sampling locations and collection methods

Cranberry Marsh (43°50'38"N; 78°57'0"W) is a 16-ha cattail (*Typha*)-dominated wetland within the Town of Whitby, Ontario (Figure 1). There are no permanent surface inflows or outflow from the marsh, although some water exchange with Lake Ontario is possible during storm surges across a low berm separating the marsh from the gravel/cobble beach of Lake Ontario. Cranberry Marsh is a provincially significant wetland managed by the Central Lake Ontario Conservation Authority and is an important nesting/feeding/resting area for resident and migrating songbirds, waterfowl

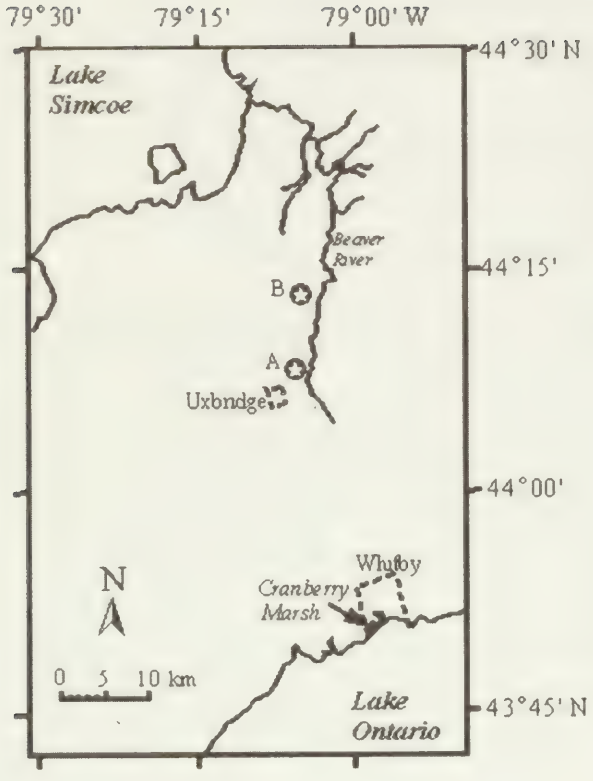

FIGURE 1. Map showing three testate rhizopod collection locations between Lake Ontario and Lake Simcoe in southern Ontario. Latitude and Longitude for Cranberry Marsh, and Sites A and B are as follows: 43°50'38"N, 78°57'30"W; 44°08'27"N, 79°05'12"W; 44°12'33"N, 79°04'40"W, respectively.

and shorebirds. Samples of water and bottom sediment were collected 7 August 2004 by submerging a wide-mouthed 500 mL bottle at the south end of Cranberry Marsh where water depth was about 0.5 m.

The Beaver River originates in a forest bog and marsh complex approximately 5 km southeast of the town of Uxbridge, Ontario (Figure 1). With a total length of approximately 50 km, a watershed area of 3.2×10^8 m^2 and a total annual discharge that averaged 8.3×10^7 m^3 year^{-1} for the 1990s (Scott et al. 2001*), the Beaver River is one of the largest rivers flowing into Lake Simcoe. Sampling for testate rhizopods was in moss pools near the upper Beaver River (Sites A and B in Figure 1) in areas of forest bog dominated by White Spruce (*Picea glauca* (Moench) Vos, Northern White Cedar (*Thuja occidentalis* L., Tamarack (*Larix laricina* (Du Roi) Koch), *Sphagnum* spp, *Hylocomium splendens*, and other forest mosses. Samples containing testate rhizopods consisted of approximately 10 cc of wet moss and 500 mL of water mixed with bottom sediment from small forest pools of 20 cm maximum depth.

Laboratory methods

Samples were examined shortly after collection in their living state with an inverted microscope. Other portions of the samples, comprising about 1 cc of sediment and 20 cc of water, were fixed with formalin to achieve a final concentration of about 4% formaldehyde. Testate rhizopods of interest for measuring, image capture or isolation for transfer to a separate permanent preparation were isolated from surrounding debris by manipulation at low power (10× objective) with a single hair brush. A single specimen of each of the two new species described here was selected to serve as the type specimen for museum archival and were transferred with a micro-pipette to a Number 1 cover glass for drying and subsequent mounting on a slide with Canada Balsam. All measurements were made at a magnification of 600× (40× objective, 1.5× microscope head, 10× eyepiece). Optimal orientation for measurement was achieved by manual manipulation of isolated specimens with a single hair brush. Descriptive statistics on measurements were run in CoStat (CoHort Software 1995*). Images were captured with a 3.4 megapixel digital camera and assembled onto plates for publication using Adobe Photoshop 5.0.

Results

Cyclopyxis acmodonta n. sp.

Phylum Rhizopoda Class, Lobosea; Order Arcellinida; Family Trigonopyxidae Loeblich and Tappan, 1964.

Diagnosis: Test constructed of agglutinated microscopic quartz granules and in side view with a flattened ventral surface and domed dorsal surface. Ventral surface with a centrally located and irregularly-shaped oral aperture (pseudostome) about ½ the test diameter and composed of from three to seven lobes or indentations. Margin of the pseudostome ornamented with many sharp-pointed tooth-like granules. Test diameter, 188-298 µm; test height, 150-217 µm; widest opening in pseudostome (between distal lobes), 75-143 µm. Pseudostome only slightly invaginated relative to the surrounding ventral surface of the test.

Etymology: The specific epithet ("acmodonta") refers to the small sharp-pointed "teeth" that embellish the interior margin of the pseudostome [acmodonta (Latin, fem. adj.) = sharp-toothed].

Type specimen: The type specimen was mounted in Canada Balsam on a glass slide and was deposited with the Invertebrate Zoology Division, Canadian Museum of Nature, Catalogue Number CMNI 2005-0004.

Holotype material: A formalin-preserved aqueous sample has been retained by the author under sample No. V-1892, collected 4 January 2004.

Type locality: Forest bog (*Sphagnum* moss dominated small pool) near the upper Beaver River, Ontario Canada (44°08'27"N, 79°05'12"W). Specimens were also collected on 16 October 2001 from a moss pool in a similar forest habitat (Site B in Figure 1; 44°12'33"N, 79°04'40"W), approximately 8 km N of the type locality.

TABLE 1. Sizes of test variables in *Arcella formosa* and *Cyclopyxis acmodonta*. n = 14 for all *A. formosa* variables; n = 18 for *C. acmodonta* except n = 14 for ap and D/ap. Definitions of D, H and ap are as depicted in Figures 2a, 2b and 4b, respectively. The pseudostomal "ap" metric for *C. acmodonta* was represented by the longest straight line joining the most remote lobes of the aperture. For those *A. formosa* specimens for which the aperture was slightly elliptical rather than circular, the longest distance through the centre was measured.

Arcella formosa	diameter (D)	height (H)	aperture (ap)	D/H	D/ap
median	192	85	58.5	2.3	3.2
minimum	165	56	46	1.9	2.5
maximum	235	100	85	3.2	3.6
mean	199.1	84.9	64.6	2.4	3.2
SD	27.3	12.4	15.6	0.4	0.4
coef. var. (%)	13.9	14.9	24.5	16.2	11.4
Cyclopyxis acmodonta	diameter (D)	height (H)	aperture (ap)	D/H	D/ap
median	260	195	118	1.4	2.2
minimum	188	150	75	1.2	1.9
maximum	298	217	143	1.5	2.5
mean	249.9	185.7	116.1	1.3	2.2
SD	32.7	21.1	17.7	0.1	0.2
coef. var. (%)	13.9	14.9	24.5	16.2	11.4

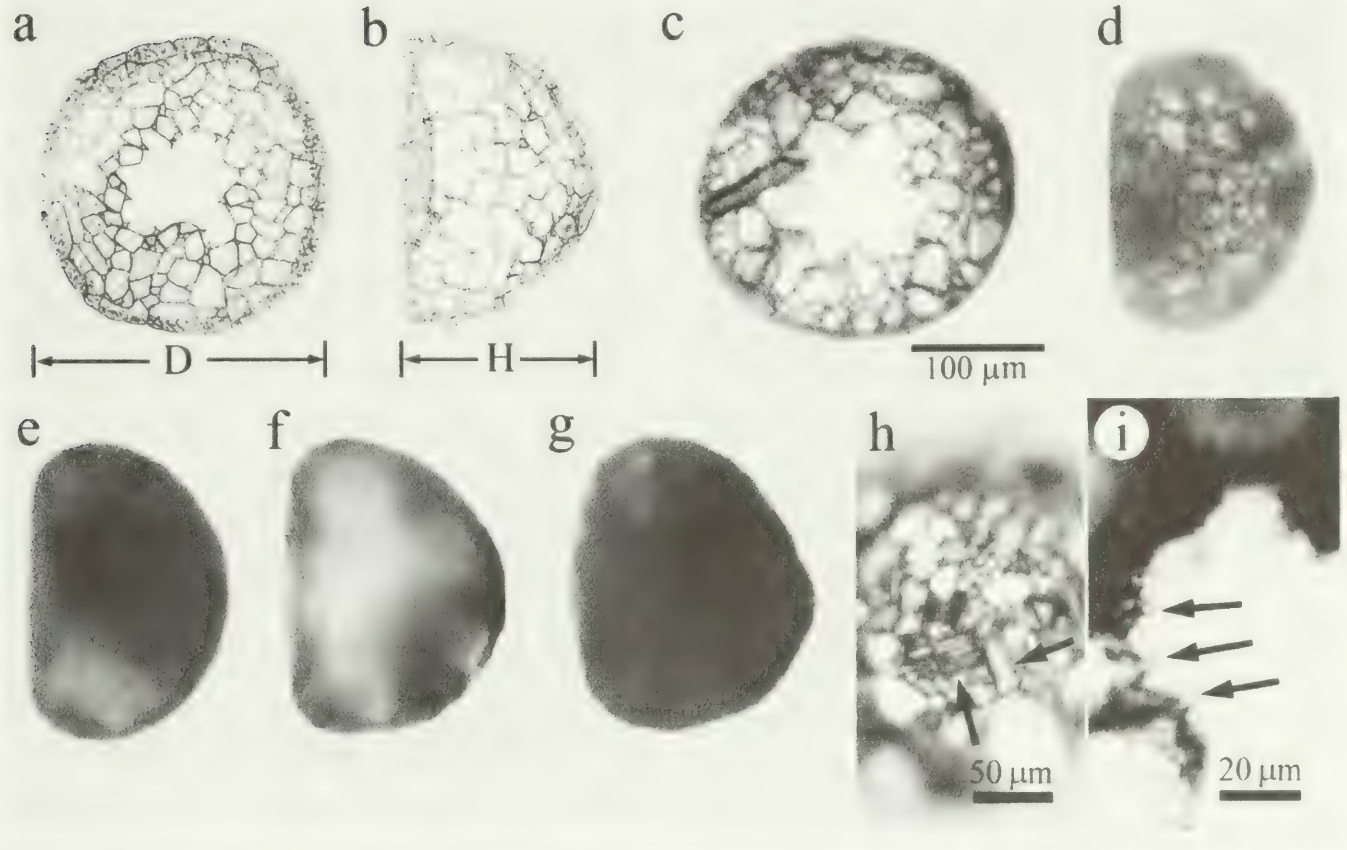

FIGURE 2. *Cyclopyxis acmodonta* tests. **a.** Drawing of the ventral view showing the irregularly lobed and centrally located pseudostomal aperture (D = test diameter). **b.** Drawing of the lateral view; the flat side is the ventral surface (H = test height). **c.** Image of the type specimen archived with the Canadian Museum of Nature (Catalogue Number CMNI 2005-0004). The scale bar in Figure 2c applies to Figures a-g. **d.** Lateral view showing agglutinated quartz granules on the test surface. **e-g.** Three different specimens in lateral view showing variation in profile shape. **h.** Details of test surface showing incorporated diatom frustules (arrows). **i.** interior margin of one lobe of a pseudostomal aperture showing three tooth- like granules (arrows).

In lateral view, the shape of the test of *Cyclopyxis acmodonta* was quite distinctive, although there was some variation in the shape of the domed dorsal surface, ranging from those with a smooth rounded form to those with a slightly more conical shape (Figures 2b,d-g). Certainly, the term hemispherical, which has been applied to several other species of *Cyclopyxis*, cannot be applied here because of *C. acmodonta*'s more exclusive shape. In a hemisphere, the diameter-to-height ratio is 2; in *C. acmodonta*, the test diameter-to-height ratio ranged from 1.2 to 1.5 with a median of 1.4 (Table 1).

The most distinctive feature of this species is the pseudostome with its highly variable and irregularly lobed margin (Figures 2a,c, 3a-i). Higher magnification revealed the many tiny sharp-pointed angular quartz grains attached to the inner margin of the pseudostome rim (Figure 2i), but these were also apparent in some specimens at lower magnification (e.g. Figures 3e,h). The number of apertural lobes ranged from three to seven (nine, if smaller subdivisions of lobes were included). The pseudostome was only slightly invaginated (<1/5 test height) relative to the surrounding ventral surface of the test.

In some specimens there was appeared to be a thin membrane-like cover over the aperture in which were embedded a few thin quartz particles and diatoms (Figure 3g). This structure may be an early component of cyst formation, whereby the aperture becomes more densely plugged at later stages of encystment. Many specimens were observed with the apertural rim only faintly visible owing to the large accumulation of test-like material over the pseudostome. Presumably, these represented a later stage of encystment. In these specimens too, the internal protoplast was dense and darkly coloured.

All tests examined were completely covered in highly refractive microscopic quartzite particles. There did not appear to be any distributional patterns in the sizes of these particles, suggesting that during test construction, the organism does not discriminate among particle sizes for specific regions of the test. Larger particles appeared to be randomly dispersed and interspersed with smaller particles over the whole of the test. Rarely were particles larger than 50 µm diameter found in tests of this species. Intact and broken diatom frustules were sometimes encountered (Figure 2h), again, with no apparent preference for either dorsal, lateral or ventral surfaces of the test.

***Arcella formosa* Nicholls, Meisterfeld & Török n. sp.**[1]

Phylum Rhizopoda; Class Lobosea; Order Arcellinida; Family Arcellidae Ehrenberg, 1830 emend. Deflandre, 1953.

Diagnosis: Test nearly colourless to dark rusty-brown in colour, constructed of circular-to-elliptical areoles, 3.0-4.5 × 2.5-3.5 µm. In ventral and dorsal views the test is generally circular in outline but with a wavy or "lumpy" margin 165-235 µm in diameter. The pseudostomal aperture consists of a thickened rim, 46-85 µm in diameter. The pseudostome is invaginated relative to the surrounding ventral surface of the test by a distance of about ¼ the test height. The internal rim of the pseudostome is recurved forming a short (3-4 µm) buccal tube. In lateral view, the test consists of a low, dome-shaped structure with multiple depressions that impart a wavy-edged appearance to the margin of the test. Test height is 56-100 µm.

Etymology: The specific epithet ("*formosa*") refers to the attractive smooth curves created by the depressions in the dorsal surface of the test [formosa (Latin, fem. adj.) = beautiful].

Type specimen: The type specimen was mounted in Canada Balsam on a glass slide and was deposited with the Invertebrate Zoology Division, Canadian Museum of Nature, Catalogue Number CMNI 2005-0003.

Holotype material: A formalin-preserved aqueous sample has been retained by the author under sample Number V-1924, collected 7 August 2004.

Type locality: South end of Cranberry Marsh, Town of Whitby, Ontario, Canada (43°50'38"N, 78°57'30"W).

The large size (median test diameter of 192 µm; Table 1) and the "lumpy" appearance of the test margins, in both ventral and lateral views (Figures 4a, b), are distinctive features of this species. There was considerable variation in the colour and degree of development of the depressions on the dorsal surface of this species. In the lighter coloured specimens (pale yellowish-grey), the dorsal depressions were less well developed (Figures 4c-f) than in the darker (brownish orange) coloured specimens, where the depressions and the thickened rims delineating their boundaries were very well defined (Figures 4g-l). The pseudostomal aperture was invaginated about ¼ of the test height and its structure included a well-developed buccal tube (Figures 4b, f). Of all measurements made on tests of

[1]After submission of this paper by K. Nicholls to *The Canadian Field-Naturalist* in February, 2005, one of the referees selected by the editor to review it (R. Meisterfeld) informed Nicholls that *A. formosa* had been previously found by him in Germany and by J. Török in Hungary. Although neither discovery had been submitted for publication, a poster presentation by Török had been made in Italy at the 4th European Congress of Protistology under the unofficial name, "*Arcella siemensmai*". The inclusion of Meisterfeld and Török as co-authorities of *A. formosa* in this paper was agreed by all as an acceptable way to acknowledge the original and preemptory submission by Nicholls as well as the independent discoveries of this taxon by Meisterfeld and Török. As a consequence, the names "*A. siemensmai*" and "*A. robusta*" previously used by Török & Meisterfeld and F. Siemensma, respectively, to describe this taxon are rendered invalid.

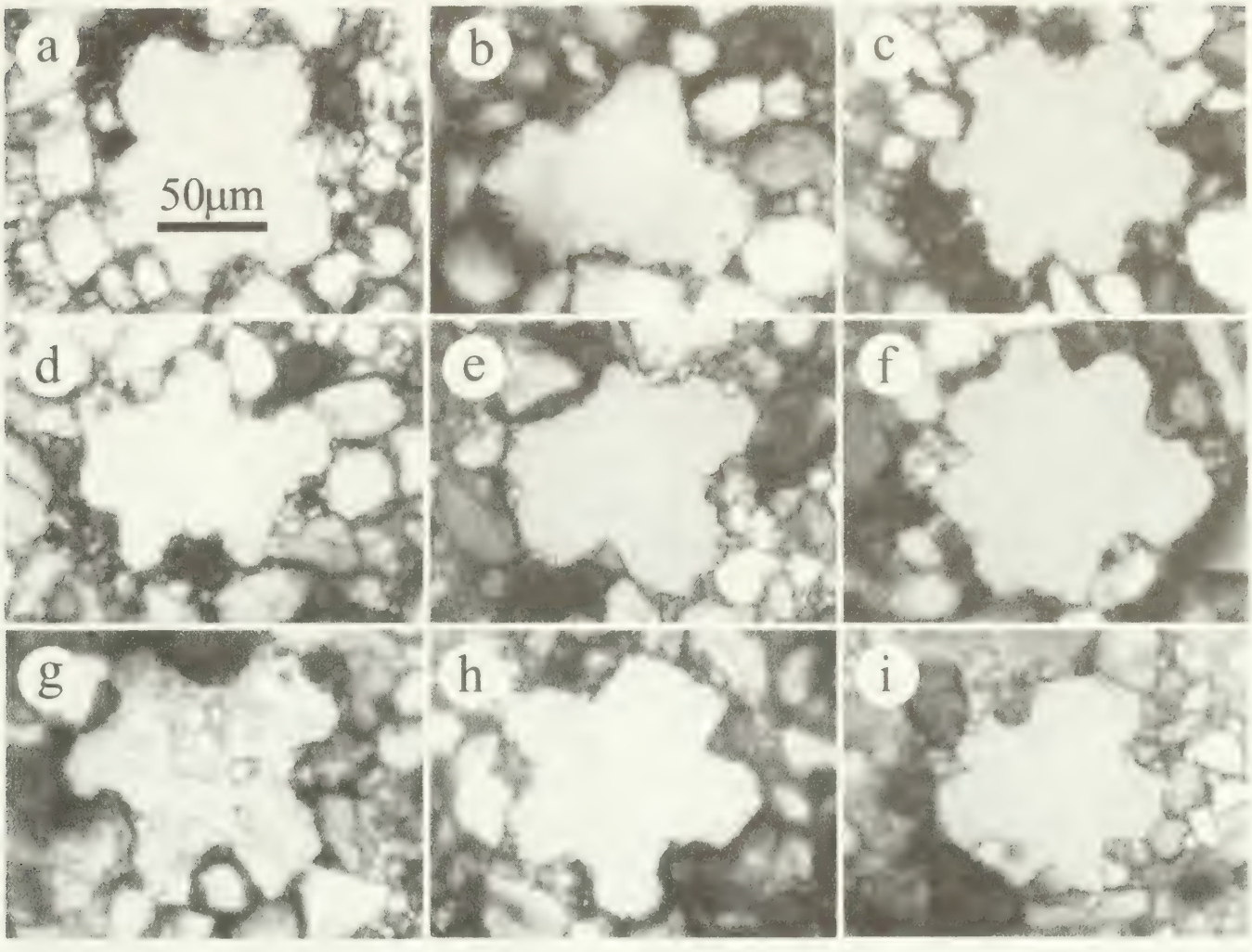

FIGURE 3. Pseudostomal apertures in nine different specimens of *Cyclopyxis acmodonta* illustrating the wide range in shape. The scale bar in Figure 3a applies to all Figures 3a-i.

this species, the greatest variation was found in the aperture diameter (coefficient of variation = 24.5%; Table 1).

The test of *A. formosa* appears to be of two major structural components: an underlying meshwork of irregularly sized and shaped meshes (Figure 5a), and an overlying sheet of elliptical-to-circular disc-like areoles averaging about 3×4 µm. Small, but well-defined pores are located at the junctions of adjacent areoles so that each areole is surrounded by usually 4-5 pores (Figure 5b). This two-layered structure was revealed in the broken test of a specimen that apparently had a large piece of the outer areolar layer stripped off (Figure 5a; but note the small patch containing the surface areolar layer in the lower right of Figure 5a).

Discussion

The genus *Cyclopyxis* contains a few large species with lobed pseudostomal apertures; consequently, the test structure of each had to be reviewed before any conclusions about the autonomy of *C. acmodonta* was established. *Cyclopyxis impressa* (Daday) Deflandre (= *Difflugia lobostoma* var. *impressa* Daday = *Centropyxis impressa* (Daday) Da Cunha) is apparently restricted to a few locations in the Southern Hemisphere (Velho et al. 1996). All reports show a much larger test (300-561 µm in diameter) than that found for *C. acmodonta*; other differences include a very regularly shaped and symmetrical pseudostomal aperture with 5-8 lobes, a much greater diameter-to-height ratio, and a much greater degree of invagination of the pseudostome (to about 50% of the test height). *Cyclopyxis trilobata* var. *maxima* Chardez, 1971, test size (D = 225-235; H = 110-140 µm) is close to *C. acmodonta*. Although Chardez (1971) did not illustrate his new taxon (to which I attribute subspecies status implied by his term "var."), he stated that *C. triblobata* var. *maxima* differed from *C. trilobata* Bartos,1963 only in its much greater size. Like its nominotypical subspecies, *Cyclopyxis trilobata* var. *maxima* has a small, well-defined, three-lobed pseudostome which clearly distinguishes it from *C. acmodonta*.

Bartos (1963) described *Cyclopyxis crucistoma* which is significantly smaller than *C. acmodonta* with a test diameter of 122-124 µm and a height of 50 µm. It also has a well-defined pseudostome in the shape of a cross. *Cyclopyxis grospietschi* (Schönborn 1962) also has a pseudostome in the shape of a cross, but its

test diameter and height are only 125 and 80 µm, respectively (significantly smaller than *C. acmodonta*). Decloitre (1954) described *Cyclopyxis lobostoma* with a 7-lobed pseudostome and a test diameter and height of 430 and 280 µm, respectively according to Bartos (1963), or 400 and 300 µm, according to Decloitre (1977). In ventral view, this species resembles *C. impressa*, but its pseudostome is apparently not invaginated. This fact is grounds for questioning its placement in the genus *Cyclopyxis*, so it needs to be rediscovered and evaluated relative to other genera in the Trigonopyxidae (possibly a *Geopyxella* species?).

As regards overall test shape and degree of invagination of the pseudostome, *C. acmodonta*'s closest "relative" would appear to be *C. stellata* (Wailes 1927) Defl. 1929. Important differences between the two species

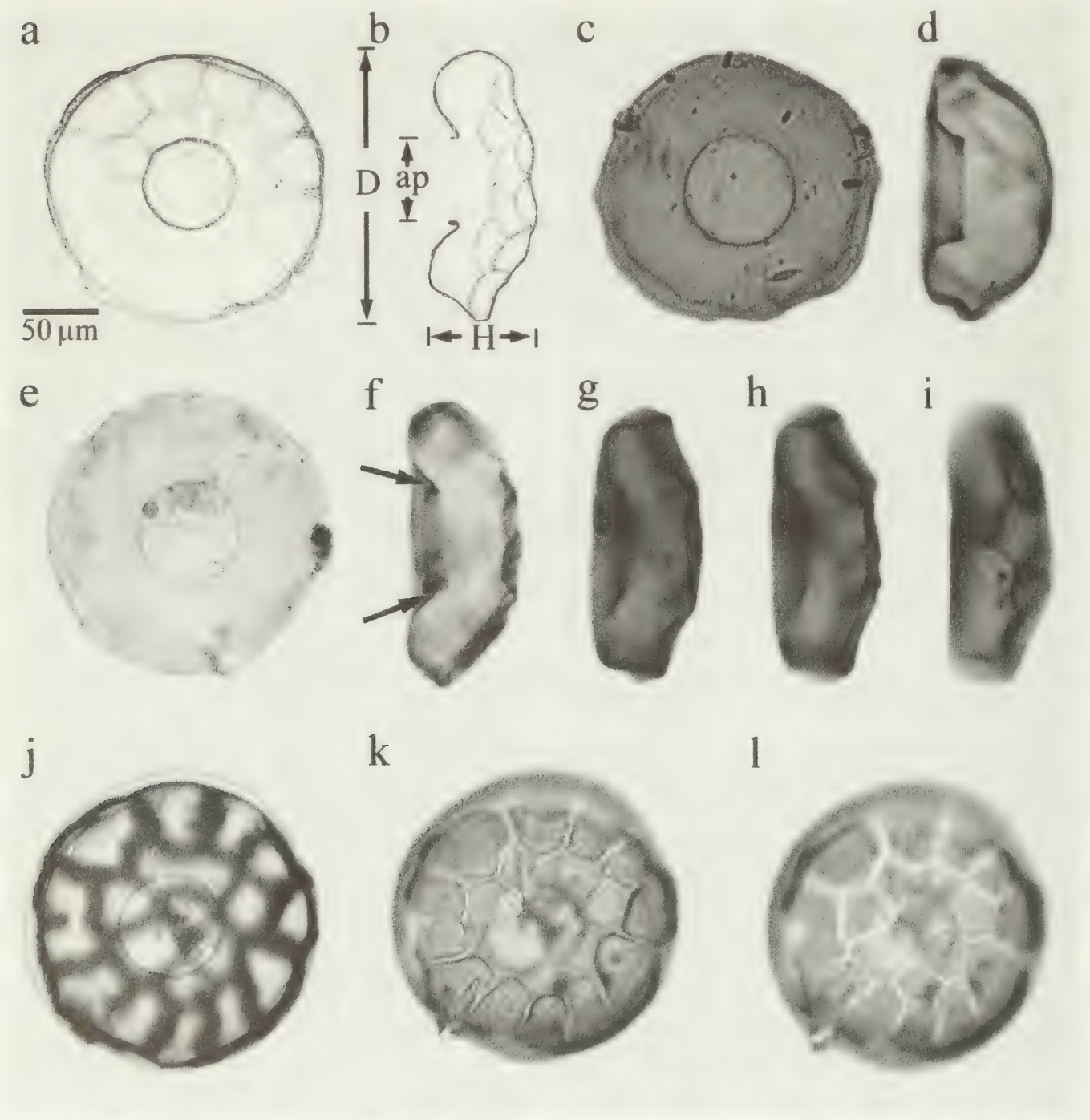

FIGURE 4. *Arcella formosa* tests. **a.** Drawing of the ventral surface (translucency of the test allows the ridges separating the depressions on the dorsal surface to be revealed; see also Figure 4j; scale bar applies to all Figures 4a-l). **b.** Drawing of the lateral view; the pseudostomal aperture (ap) is on the ventral surface; D = test diameter; H = test height. **c.** Image of the ventral view of a test. **d.** Image of the lateral view of the same specimen illustrated in Figure 4c. **e.** Image of the ventral view of a different specimen. **f.** Image of the lateral view of the same specimen illustrated in Figure 4e; arrows indicate the location of the buccal tube. **g-i.** Images of the lateral view of a different specimen at three different levels of microscopic focus. **j-l.** Images of the ventral side (j), sub-dorsal (k), and dorsal (l) surfaces of the same specimen illustrated in Figures 4 g-i.

are as follows: (1) *C. stellata* has a pseudostomal aperture with 3-5 well-defined lobes while *C. acmodonta*'s aperture is irregularly shaped. (2) The distinctive sharp-pointed granules ornamenting the internal margin of the pseudostome in *C. acmodonta* are apparently not present in *C. stellata*. (3) With test diameters and heights of 335-400 and 252-290 µm, respectively, *C. stellata* is significantly larger than *C. acmodonta*; the smallest *C. stellata* tests are larger than the biggest *C. acmodonta* tests. (4) Wailes (1927) described the test of *C. stellata* as being "composed of irregularly shaped siliceous plates, without protuberances". In *C. acmodonta*, although there were some flat plate-like particles seen, the test elements are more aptly described as "irregularly shaped polygonal particles".

In a review of the variability and taxonomy of several smaller species of *Cyclopyxis*, Foissner and Korganova (1995) found a wide range of sizes among some species. They concluded that size criteria may be of limited value in distinguishing among certain species unless the differences are very distinct, and/or the size difference is accompanied by at least one other reliable morphologic character. It is not known how such criteria might apply to the larger *Cyclopyxis* species with lobed pseudostomal apertures, because measurements of large numbers of specimens and the appropriate follow-up statistical analyses have not been published for most. With the literature data available, however, *C. acmodonta*'s test size and other morphometric features (pseudostome shape and degree of invagination) clearly set this species apart from other similar *Cyclopyxis* species.

Unfortunately the nomenclature of the three *Centropyxis* species (*C. stellata* Wailes, *C. arcelloides* Pénard and *C. impressa* (Daday) Da Cunha) transferred to *Cyclopyxis* by Deflandre (1929) is somewhat confused. Undoubtedly this confusion stems from Deflandre's own treatment of *Cyclopyxis* in later years. Since the erection of *Cyclopyxis* in 1929, virtually all students of the Arcellinida have considered *Cyclopyxis* a separate and well defined genus (Decloitre (1977). Deflandre's post-1929 treatment of *Cyclopyxis*, however, remains ambiguous. Deflandre (1953) acknowledged that other authors had treated *Cyclopyxis* and *Centropyxis* as separate and distinct genera, but by this date (1953) Deflandre himself apparently still had not accepted this. He did not list *Cyclopyxis* anywhere in his classification of the Testacealobosa, except noting its existence in a footnote to the genus *Centropyxis*, within which he continued to submerge it. Several years later, in his comprehensive summary and key of freshwater testate rhizopods, Deflandre (1959) did not list any *Cyclopyxis* species but named two *Cyclopyxis* species under *Centropyxis* (*Centropyxis stellata* Wailes and *Centropyxis arcelloides* Penard).

Other sources of confusion include (1) Harnisch (1958), who considered *Cyclopyxis* a subgenus of *Centropyxis*, and, like Deflandre (1959) listed "*Centropyxis stellata* Wailes", and (2) Chardez (1967) who

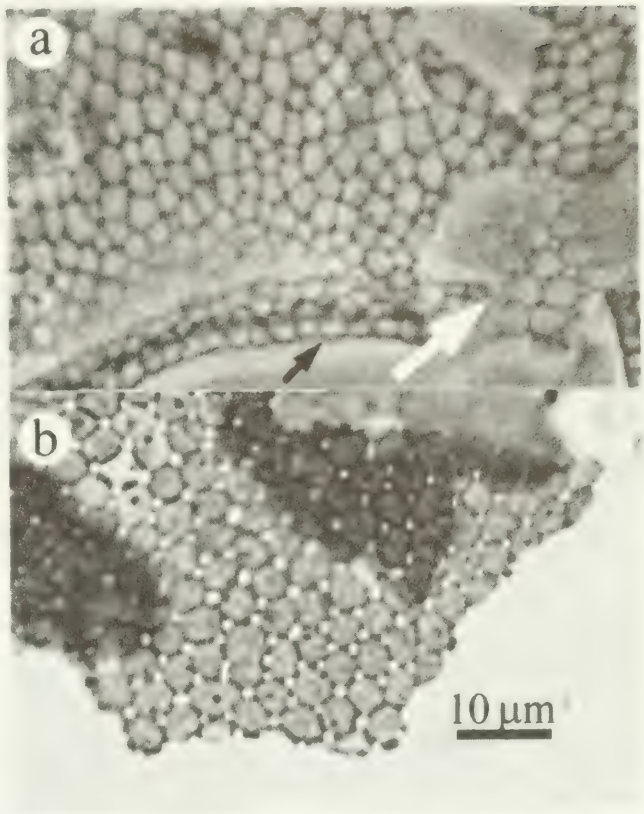

FIGURE 5. Microscopic structure of the test wall of *Arcella formosa*. **a**. Underlying meshwork of test wall showing variation in shape and size of meshes. Small black arrow points to the interior rim of the pseudostomal aperture with its palisade layer of meshes. Larger white arrow points to a small patch of overlying subcircular areoles. **b.** Piece of broken test wall showing the arrangement of circular to elliptical areoles with interspersed pores. Scale bar applies to both Figures 5a and b.

listed "*Cyclopyxis stellata* Wailes" despite the fact that Wailes had described it as a *Centropyxis* species and that it had not previously been formally assigned to *Cyclopyxis* as a new combination. Chardez (1967) listed *Centropyxis* and *Cyclopyxis* as distinct genera in the family Centropyxidae, but listed 12 other genera, 11 of which had not been included in Deflandre's (1953) original concept of the family. Chardez (1967, and later papers) did not formally revise the description of the Centropyxidae to include the broadened range of form implied by inclusion of the 11 additional genera.

Although Jung (1942) first introduced the family name Centropyxidae, with the result that Jung (1942) is sometimes listed as the authority for this family (e.g., Bovee 1985; Meisterfeld 2002), the correct authority is Deflandre (1953) who first provided a formal circumscription and included four genera. More recently, however, the family Centropyxidae has implicitly become better defined with the recognition that several genera originally on Chardez's (1967) list of Centropyxidae could be more naturally accommodated within the family Trigonopyxidae Loeblich and Tappan, 1964.

In the future, in order to correct some of the problems outlined above, students of the taxonomy of these arcellinid families should list the authority for the Cen-

tropyxidae as follows: "Centropyxidae Deflandre, 1953 sensu Meisterfeld 2002", in order to reflect its contemporary generic composition. As well, species transferred from *Centropyxis* to *Cyclopyxis* by Deflandre (1929) should be rendered in accordance with Article 51 of the Interntional Code of Zoological Nomenclature (ICZN) as a combination attributed to Deflandre; e.g., *Cyclopyxis arcelloides* (Penard) Deflandre, as listed in Jung (1942) and Laminger (1972), for example, and not as *Cyclopyxis arcelloides* Penard, as listed in Chardez (1967), Bonnet (1977), and Coûteaux and Chardez (1981). Species of *Cyclopyxis* described after Deflandre (1929) should not pose any nomenclatural or authorship difficulties because no new combinations are required (e.g., *Cyclopyxis crucistoma* Bartos, 1963).

There are virtually no *Arcella* species that can be confused with *A. formosa*. Firstly, its large size is highly unusual among representatives of the genus. Only *A. artocrea* Leidy emend. Deflandre, *A. rota* Daday, *A. megastoma* Penard, *A. leidyana* Deflandre and *A arenaria* var. *grandis* Bunescu & Matis are of comparable size. All of the above-listed species have markedly different test shapes including much greater or lesser test diameter-to-height ratios, much smaller pseudostomal apertures of different structure (e.g., greater degree of invagination on the ventral surface, presence of large pores surrounding the aperture rim).

Many *Arcella* species have dorsal surfaces ornamented with shallow depressions separated in some cases by thickened ridges on the test wall. Some of these include *A. crenata* Playfair, *A. bathystoma* Deflandre, *A. artocrea* Leidy ssp. *pseudocatinus* Deflandre and *A. gibbosa* Penard, among several others. Again, these all have major size and structural differences that clearly set them apart from *A. formosa*. The degree of form variation in *A. formosa* was objectively quantified in 14 randomly encountered specimens and subjectively evaluated in several more specimens so that there can be little doubt that its morphology is distinct and separate from any previously described species.

Species that are very small in size likely have a great potential to be overlooked in investigations of testate rhizopods. When new species of small-sized taxa are discovered, conclusions about geographic distribution may not generally be possible because of the potential for such species to exist in many habitats over large geographic areas, but to have escaped previous detection because of their small size. Because of their large sizes, both *A formosa* and *C. acmodonta*, on the other hand, were readily detected in the Ontario samples. Recognizing that many species of *Arcella* and *Cyclopyxis* (earlier as *Centropyxis*) were known to science nearly a century ago, if *A. formosa* and *C. acmodonta* were widespread in other habitats in other parts of the world, they should have been detected by others long ago (notwithstanding the recent discoveries of *C. acmodonta* in Hungary and Germany: (R. Meisterfeld, personal communication). The logical conclusion is that Cranberry Marsh and the Beaver River coniferous forest bogs afford these species certain environmental tolerances or requirements not widely available elsewhere. This lends support to the widely held view among local naturalists and biologists familiar with the botanical and avian attributes of these habitats that these are areas of unique biological status deserving of special protection and further scientific investigation.

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Received 11 February 2005
Accepted 15 August 2005

A Range Extension for the Rock Vole, *Microtus chrotorrhinus*, in Labrador

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Lansing, Sarah W. 2005. A range extension for the Rock Vole, *Microtus chrotorrhinus*, in Labrador. Canadian Field-Naturalist 119(3): 412-416.

Rock Voles (*Microtus chrotorrhinus*) were previously documented only from the southern coast of Labrador and the Strait of Belle Isle south of Hamilton Inlet. During two field seasons in 2000 and 2001, both in July, six Rock Vole specimens were collected on Southern Island, off the north-central coast of Labrador, extending the range of the subspecies *Microtus chrotorrhinus ravus* approximately 250 km to the central Labrador coast north of Hamilton Inlet. Rock Voles were trapped primarily in stunted Black Spruce (*Picea mariana*) forest and areas associated with rocks, thick brush, and water.

Key Words: Rock Vole, *Microtus chrotorrhinus*, Labrador, distribution.

Rock Voles (*Microtus chrotorrhinus*) occur from the Ungava Peninsula of Labrador to the southeastern United States, and west into Minnesota, but their distribution in Labrador is not well documented. Two subspecies of *Microtus chrotorrhinus* are currently recognized in Canada: *M. chrotorrhinus chrotorrhinus*, distributed widely across eastern Canada and into the midwestern portions of the United States (Anderson 1946; Banfield 1974; Kirkland and Jannett 1982; Komarek 1932) and *M. chrotorrhinus ravus*, recorded only from the Ungava Peninsula of Labrador and apparently restricted to the coastal regions (Anderson 1946; Banfield 1974; Kirkland and Jannett 1982; Komarek 1932). In this study, Rock Voles were trapped in the Adlavik Islands, Labrador, and are most likely identified to *M. chrotorrhinus ravus*, which is known from the type locality of Black Bay, Strait of Belle Isle, and from L'Anse-au-Loup, Red Bay, Mary's Harbour, and Hare Harbour, Labrador (Anderson 1946; Harper 1961; Peterson 1962; Whitaker and Martin 1977). Banfield (1974) documented *M. chrotorrhinus ravus* on Anticosti Island in the Gulf of St. Lawrence, but Cameron (1958) did not collect this subspecies on the island. To my knowledge, the only confirmed island population of Rock Voles has been reported from Cape Breton Island, Nova Scotia (Roscoe and Majka 1976). Thus, not only does this study extend the range of Rock Voles farther north in Labrador but also documents a second population of Rock Voles on an island.

Throughout their range, Rock Voles are generally associated with habitats that feature rocks or talus slopes (Kirkland 1977; Kirkland and Knipe 1979; Roscoe and Majka 1976; Timm et al. 1977). Rock Voles usually occur in moist mossy areas near streams and ponds, thick brush, and open-canopy forests (Buech et al. 1977; Kirkland and Jannett 1982; Kirkland and Knipe 1979), although Nagorsen and Peterson (1981) collected Rock Voles on ridges of dry upland coniferous forest near lake margins. Groundcover and berry plants are an important component of Rock Vole microhabitats. Rock voles are often trapped in association with important food sources, including Labrador Tea (*Rhododendron groenlandicum*), Bunchberry (*Cornus canadensis*), Bakeapple or Cloudberry (*Rubus chamaemorus*), Alpine Bilberry (*Vaccinium uliginosum*), and Partridgeberry (*Vaccinium vitis-idaea*) (Kirkland and Jannett 1982; Timm et al. 1977; Whitaker and Martin 1977). Roots, seeds, grass stems and leaves, and larvae of insects have also been recorded in the stomach contents of Rock Voles (Whitaker and Martin 1977).

Study Area

During two field seasons in Labrador, surveys of small mammals were conducted in the vicinity of Adlavik Harbour (55°01'N, 58°49'W; Datum: NAD 27; see also Canada, Surveys and Mapping Branch 1964a,b) on Southern Island in the Adlavik Islands (Figure 1). The Adlavik Islands consist of 11 primary landmasses and are off the north-central coast of Labrador, approximately 25 km south of the small coastal community of Makkovik (Figure 1). From the most southern point on Southern Island to the nearest point on the mainland is 3.75 km. Trapping sites are approximately 10 km from the mainland. During the winter, Southern Island is connected to the mainland by ice, which would allow small mammals to traverse from the mainland to the islands.

The Adlavik Islands are characterized by stands of stunted black spruce (*Picea mariana*) forest that shelter dwarf thickets and brush, carpets of moss and lichen, and rocky tundra on the upper slopes and summits of the hills; habitat that is consistent with previous descriptions of vegetational communities along the central Labrador coast (Fitzhugh 1972; Tanner 1947). The Ecological Stratification Working Group (1996) places the Adlavik Islands in the taiga shield ecozone, specif-

ically the coastal barrens ecoregion, which is characterized by long cold winters and short wet summers. Mean temperatures range from –13.5°C in the winter to 7°C in the summer and annual precipitation can range from 600-1000 mm (Ecological Stratification Working Group 1996). The coastal barrens are part of the Atlantic low subarctic ecoclimatic region and are dominated by stands of black spruce and understories of Dwarf Birch (*Betula* sp.), Labrador Tea, Lichen (*Cladina* sp.), and moss (Ecoregions Working Group 1989).

Methods and Results

Small mammals were trapped from 11 July to 27 July 2000 and from 4 July to 22 July 2001. Trapping sites were located in representative vegetational communities on the hillside above Adlavik Harbour. During the 2000 field season, five traplines were set 0.08 km SW of Adlavik Harbour (55°01.426'N, 58°49.050'W, Datum: NAD 27) at an elevation between 15 and 20 m above sea level. Four traplines with 10 traps each ran vertically up the hill; two traplines with five and four traps, respectively, were initially located on open, moist, grass-covered rocks of the lowland coastline, approximately 3 m above sea level. After two days, these latter two traplines were condensed into one trapline now with 10 traps and positioned horizontally across the hill near the other lines, as specimens were not trapped along the coastline. Each of the five traplines encompassed multiple microhabitats such that 19 traps were set in dense microhabitat (thick stunted spruce forest microhabitat with numerous water sources), 27 traps in less dense microhabitat (typically more open bush microhabitat with thick brush, mosses and lichens, and rocks), and four traps in open microhabitat (microhabitat with dry, gravelly soil beneath boulders with little or no brush). Traps were not set along the summit of the hill, which was only sparsely vegetated.

During the 2001 field season, five traplines (0.15 km SW of Adlavik Harbour, 55°01.419'N, 58°48.976'W) were set adjacent to the trapping area of the 2000 field season at an elevation between 15 and 40 m above sea level. Four traplines were positioned horizontally across the hill and 1 line ran vertically up the hill. After five days of trapping, one trapline was moved to the rocky knoll next to camp (0.56 km NE of Adlavik

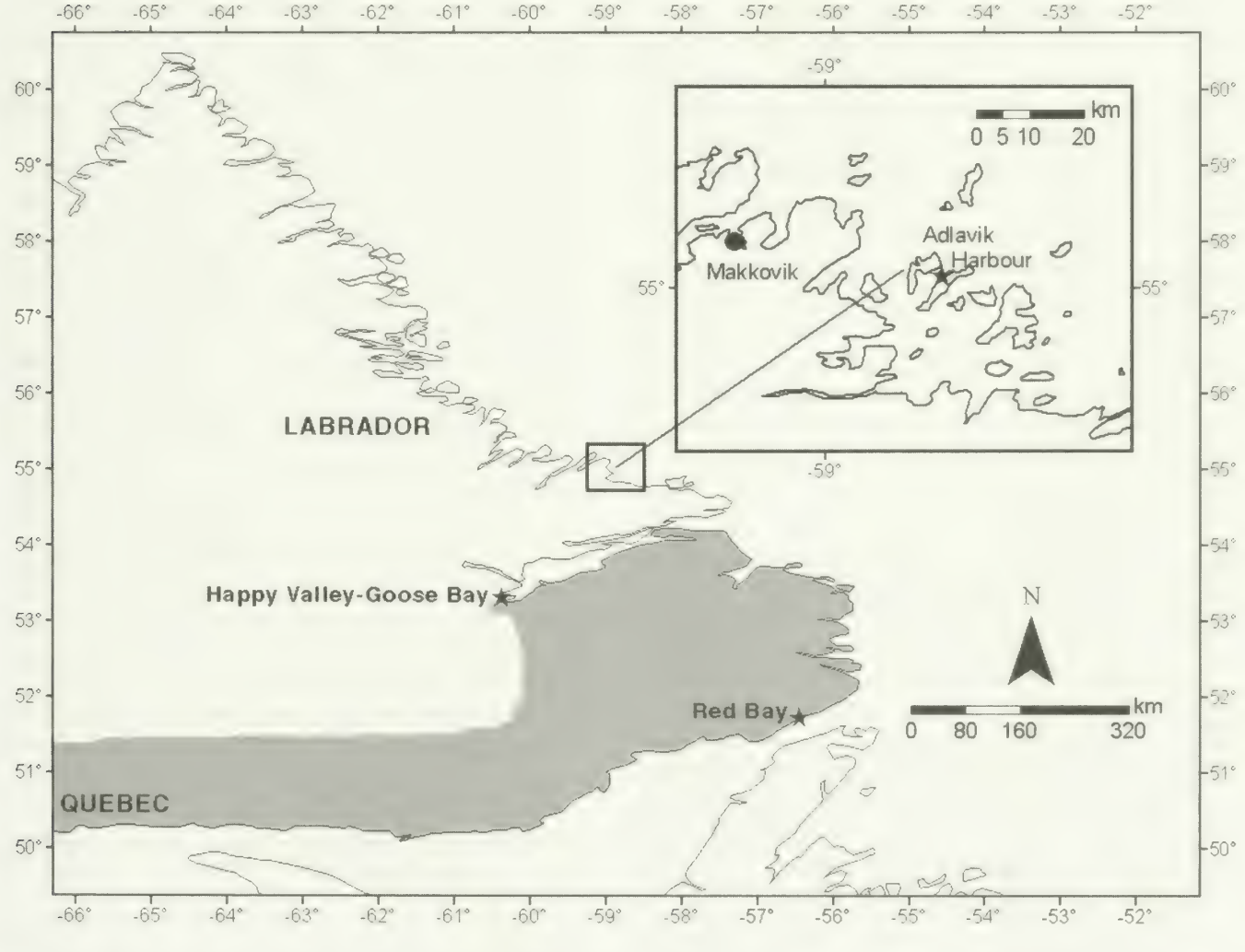

FIGURE 1. Map showing the previously documented range (gray shading) of Rock Voles (*Microtus chrotorrhinus*) in Labrador and the current trapping results in the vicinity of Adlavik Harbour, Southern Island.

TABLE 1. Total length (TL), tail vertebra length (TV), hindfoot length (HF), ear length (EAR), and weight (WT) of male and female *Microtus chrotorrhinus* from Southern Island.

	TL	TV	HF	EAR	WT (g)
Adult Female					
FMNH 168637	149	44	20	18	33
FMNH 168638	149	50	21	16	39
FMNH 176626	127	41	21	15	19
Mean	**141.67**	**45**	**20.67**	**16.33**	**30.33**
Sub-adult Female					
FMNH 168640	132	35	21	15	20
Juvenile Male					
FMNH 168639	119	35	20	13	15
FMNH 168641	118	40	22	15	22

Harbour; 55°01.757'N, 58°49.217'W; 10 m) and 2 of the remaining lines were shifted to the same spruce and open bush habitat sites that were trapped in 2000 and were oriented vertically up the hill. From 4 July to 8 July 2001, traps were set in dense spruce microhabitat (n=11), in less dense bush microhabitat (n=33), and in open habitat of boulders and gravel (n=6). From 11 July to 22 July 2001, traps were located in dense spruce microhabitat (n=22), in less dense bush microhabitat (n=14), and in open microhabitat (n=14). All 10 traps on the rocky knoll above camp were on a talus slope in open microhabitat with boulders and gravel.

Each trapline usually consisted of 10 Museum Special traps spaced at 5-m intervals; traplines were approximately 10 m apart. Traps were placed in different microterrains, including beneath rock overhangs, beside logs, along runways in the vegetation, and under small bushes and brush. If traplines were vertical to the slope of the hill, traps were also vertically oriented and vice versa for horizontally positioned traplines. Traps were baited with a mixture of peanut butter and rolled oats and checked twice per day, once in the early morning and once in the early evening. Specimens were prepared as skins and skeletons or as fluid specimens in the field. Skeletons and skulls were cleaned by a dermestid beetle colony at the Field Museum of Natural History. Cleaned skulls were measured, following the methods in Martin, Pine, and DeBlase (2001), using Mitutoyo digital calipers to the nearest 0.01 mm. Specimens are deposited at the Field Museum of Natural History in Chicago, Illinois, USA (museum numbers: 2000 – FMNH 168599-168649, 2001 – FMNH 176624-176629).

During the 2000 field season, 51 small mammals, representing six species were trapped: Pygmy Shrew (*Sorex hoyi*, n=10), Deer Mouse (*Peromyscus maniculatus*, n=7), Southern Red-backed Vole (*Clethrionomys gapperi*, n=21), Rock Vole (n=5), Meadow Vole (*Microtus pennsylvanicus*, n=1), and Heather Vole (*Phenacomys intermedius*, n=7). During trapping in 2000, four Rock Voles were found in dense habitats of stunted spruce forest, thick brush, mosses, lichens, and berry plants with intermittent water sources and one was in relatively thick brush near trickling water. Three Rock Voles were trapped beneath rock overhangs and two beneath bushes in more open habitat. The Rock Voles (n=5) obtained include adult females (n=2), subadult females (n=1), and juvenile males (n=2). Two female Rock Voles displayed large mammae, perforated vaginas, and no embryos (FMNH 168638 and 168640). One female had small mammae, an imperforated vagina, and no embryos (FMNH 168637). Two males had scrotal testes (FMNH 168639: testes size 7 mm long by 5 mm wide; FMNH 168641: testes size 11 mm long by 6 mm wide).

During the 2001 field season, only 6 individuals were trapped: Deer Mouse (n=5) and Rock Vole (n=1). The single Rock Vole was trapped in dense habitat of stunted spruce forest beneath a rock overhang and a stunted spruce. This individual was an adult female with small mammae, a perforated vagina, and no embryos.

Body measurements of Rock Voles from different age classes are presented in Table 1. Several other studies have reported similar body measurements for this species (Banfield 1974; Kirkland 1977; Kirkland and Jannett 1982; Komarek 1932; Timm 1974; Timm et al. 1977). Cranial measurements of adult female Rock Vole specimens are presented in Table 2. Skulls were measured only if all sutures were fused, indicating adult status. Komareck (1932) reports average cranial measurements for seven specimens of Rock Voles of unknown sex and Timm (1974) documents select cranial measurements for a male and female Rock Vole, which are similar to the sampled Adlavik specimens. Although body and cranial measurements for the adult female Rock Vole trapped in 2001 are small in comparison to the two adult females from 2000, the specimen exhibits equivalent fusion of cranial sutures, degree of toothwear, and closure of dentine triangles on molars. Since the small mammal population appears to have declined on Southern Island in 2001, changes in resource availability could have contributed to the small size of the adult female Rock Vole trapped during that field season.

Discussion

In this study, Rock Voles were trapped in rocky wet habitats associated with dense cover or under thick bushes in more open areas. As noted by most authors

TABLE 2. Cranial measurements of three adult female *Microtus chrotorrhinus* from Southern Island.

Skull Measurements	FMNH 168637	FMNH 168638	FMNH 176626	Range
Greatest length of skull	24.57	24.83	23.72	23.72 - 24.83
Condylobasal length	24.87	25.15	23.67	23.67 - 25.15
Least interorbital breadth	3.74	4.01	3.92	3.74 - 4.01
Nasal length	7.41	7.39	6.86	6.86 - 7.41
Palatal length	12.55	12.82	12.44	12.44 - 12.82
Mastoid breadth	10.92	10.88	10.21	10.21 - 10.92
Zygomatic width	13.67	14.44	12.92	12.92 - 14.44
Basilar length	22.02	22.24	21.01	21.01 - 22.24
Basal length	23.35	23.64	22.54	22.54 - 23.64
Maxillary tooth row	5.67	6.00	5.64	5.64 - 6.00
Mandible length	13.33	14.14	12.74	12.74 - 14.14

(for an exception, see Nagorsen and Peterson 1981), across their range Rock Voles prefer rocky densely covered environments with abundant water sources (Kirkland and Jannett, 1982; Kirkland and Knipe, 1979; Timm et al., 1977). The Ecological Stratification Working Group (1996) notes that steep talus slopes, usually a component of Rock Vole habitat, are a common feature of the coastal barrens ecoregion.

The winter prior to the 2001 survey was very harsh, exceptionally cold and snowy, which could explain the paucity of small mammals trapped that season. Voles are known to cycle through high and low population densities, although the causes of cyclic population fluctuations are still debated. Pruitt (1972) documented synchronous fluctuations in small mammal populations on the island of Newfoundland and mainland Labrador, which are separated by the Strait of Belle Isle. Pruitt (1972) suggests that changes in ecosystem productivity could be the primary factor controlling population fluctuations.

Prior to this study Rock Voles were documented only from south of Hamilton Inlet in Labrador and from one coastal island. The surveys on Southern Island extend the range of Rock Voles approximately 250 km north of Hamilton Inlet and provide the second record of Rock Voles on a coastal island. Southern Island is located in close proximity to mainland Labrador and ice connects both landmasses during the winter such that small mammals could become established on islands. Since many of the Adlavik Islands are not far apart and close to mainland and share similar habitat features, Rock Voles could be expected to occur on other islands. Future sampling in Labrador could expand the known distribution of Rock Voles farther north in Labrador and provide further data on diet, habitat preferences, and measurements.

Acknowledgments

The Inland Fish and Wildlife Division of the Department of Tourism, Culture, and Recreation of Newfoundland and Labrador granted permission for this study. I am most grateful to Robert Otto, Labrador Senior Wildlife Biologist of the Inland Fish and Wildlife Division, for permission to trap small mammals and for encouraging research by an undergraduate student. Trapping equipment and supplies were provided by the Field Museum of Natural History, Division of Mammals. I thank Bill Stanley for all his help in field preparations and specimen identification. These surveys simultaneously occurred with archaeological fieldwork, directed by Stephen Loring and Leah Rosenmeier, at Adlavik Harbour. Many thanks to Leah Rosenmeier for constructing a map for this paper. I thank Stephen Loring, Leah Rosenmeier, Larry Heaney, and the Adlavik Island field crew for their support and many useful suggestions. I am very grateful to Bill Stanley, Barbara Lundrigan, Stephen Loring, and Russ Van Horn for their comments on previous drafts of this paper. I also wish to thank David Nagorsen and two anonymous reviewers for very helpful revisions of this manuscript.

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Received 29 December 2003
Accepted 20 July 2005

New Records of Vascular Plants in the Yukon Territory VII

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William J. Cody, Bruce A. Bennett, and Phil Caswell. 2005. New records of vascular plants in the Yukon Territory VII. Canadian Field-Naturalist 119(3): 417-436.

Based on field reconnaissance mainly in 2003 in Kluane National Park but also many other areas throughout the Yukon, information is provided on geographically significant plant occurrences. Thirteen native taxa, *Agrostis humilis*, *Blysmopsis rufa*, *Carex bebbii*, *C. lenticularis* var. *dolia*, *C. nigricans*, *C. sartwellii*, *C. siccata*, *Diphasiastrum sitchense*, *Najas flexilis*, *Oxytropis arctica* var. *arctica*, *Oxytropis arctica* var. *murrayi*, *Saxifraga nelsoniana* ssp. *carlottae* and *Swertia perennis* and two introduced taxa, *Bromus japonicus* and *Leymus mollis* ssp. *mollis* s.l. are reported new to the flora of the Yukon Territory. Significant range extensions for 109 native and eight introduced taxa are included and three species, *Clematis occidentalis*, *Polygonum persicaria*, and *Verbena hastata* are deleted from the flora.

Key Words: Vascular plants, Yukon Territory, flora, new records, range extensions, phytogeography.

Since the writing of *New Records of Vascular Plants in the Yukon Territory VI* (Cody et al. 2004), a considerable number of plant specimens have been submitted to Cody for identification and confirmation. The major submissions include the following locations and collectors: (1) Kluane National Park and vicinity by Phil Caswell and Bruce A. Bennett for the National Park Service as part of ongoing botanical inventories; (2) various locations by Reidar Elven and Heidi Solstad visiting from the University of Oslo, Norway; (3) Bruce A. Bennett collected plant specimens from throughout the territory; and (4) Greg Brunner from the Dawson City area.

This paper serves to further update the *Flora of the Yukon Territory* (Cody 1996) and *Flora of the Yukon Territory, Second Edition* (Cody 2000) along with other records recently published (Cody et al. 1998, 2000, 2001, 2002, 2003, 2004). The floristic information presented earlier and updated here provides the basis for biological research and ongoing work relating to wildlife management, forestry, sustainable resource management and agriculture. With additions of thirteen native and two introduced species reported here the flora now includes 1195 species.

The taxa addressed in the body of this paper appear in a synoptic list by Yukon status in alphabetical order. The taxa are then discussed in taxonomic order, as presented in the *Flora of the Yukon Territory* with citation of specimens and other pertinent information. Common names follow Cody (1996), Douglas et al. (1998-2001) and Kartesz and Meacham (1999).

Synoptic List by Yukon Status

Native Taxa New to the Yukon Territory (13):

Agrostis humilis
Blysmopsis rufa (*Scirpus rufus*)
Carex bebbii
Carex lenticularis var. *dolia*
Carex nigricans
Carex sartwellii
Carex siccata
Diphasiastrum sitchense (*Lycopodium sitchense*)
Najas flexilis
Oxytropis arctica var. *arctica*
Oxytropis arctica var. *murrayi*
Saxifraga nelsoniana ssp. *carlottae*
Swertia perennis

Introduced Taxa New to the Yukon Territory (2):

Bromus japonicus
Leymus mollis ssp. *mollis* s.l.

Range Extensions of Native Taxa within the Yukon Territory (109):

Angelica lucida
Antennaria pulcherrima
Aphragmus eschscholtzianus
Apocynum androsaemifolium
Arabidopsis salsuginea
Arabis boivinii
Arnica diversifolia
Arnica latifolia
Artemisia tilesii
Astragalus alpinus
Athyrium filix-femina var. *cyclosorum*
Campanula rotundifolia
Carex brunnescens
Carex buxbaumii
Carex canescens
Carex eburnea
Carex lasiocarpa
Carex laxa
Carex lenticularis var. *lipocarpa*
Carex livida
Carex microglochin
Carex microptera

Carex nardina
Carex parryana
Carex phaeocephala
Castilleja miniata
Castilleja parviflora
Castilleja unalaschcensis
Cirsium foliosum
Coeloglossum viride ssp. *bracteatum*
Comandra umbellata ssp. *pallida*
Cryptogramma crispa var. *sitchensis*
Douglasia ochotensis
Draba albertina
Draba cinerea
Draba crassifolia
Draba lonchocarpa var. *vestita*
Draba nivalis
Draba oligosperma
Draba scotteri
Draba stenoloba
Draba stenopetala
Drosera anglica
Dryas integrifolia ssp. *crenulata* (*Dryas crenulata*)
Dryas octopetala ssp. *hookeriana* (*Dryas hookeriana*)
Epilobium hornemannii ssp. *hornemannii*
Erigeron grandiflorus ssp. *arcticus*
Erigeron humilis
Erigeron peregrinus ssp. *peregrinus*
Erigeron pumilus
Erigeron uniflorus ssp. *eriocephalus*
Erigeron yukonensis
Eriophorum gracile
Festuca brachyphylla
Festuca brevissima
Festuca minutiflora
Galium triflorum
Geranium erianthum
Harrimanella stellariana
Hieracium gracile
Iris setosa ssp. *interior*
Juncus bufonius
Juncus filiformis
Leptarrhena pyrolifolia
Luetkea pectinata
Lupinus nootkatensis
Luzula piperi
Luzula spicata
Menyanthes trifoliata
Minuartia dawsonensis
Myriophyllum verticillatum
Nuphar variegatum
Orobanche fasciculata
Oxytropis campestris ssp. *jordalii*
Oxytropis nigrescens ssp. *nigrescens*
Papaver radicatum ssp. *kluanensis*
Parnassia fimbriata
Phippsia algida
Phyllodoce × *intermedia*
Pinus contorta ssp. *latifolia*
Plantago eriopoda
Polemonium pulcherrimum
Polygonum achoreum
Polygonum lapathifolium
Polystichum lonchitis
Potamogeton praelongus
Potentilla bipinnatifida
Primula nutans
Rosa woodsii
Rumex maritimus ssp. *fueginus*
Sagina nivalis
Salix niphoclada
Saxifraga nelsoniana ssp. *pacifica*
Saxifraga rufopilosa
Schoenoplectus acutus (Scirpus acutus)
Schoenoplectus tabernæmontani (Scirpus validus)
Tricaphorum alpinum (Scirpus hudsonicus)
Silene acaulis ssp. *subacaulescens*
Sorbus sitchensis
Stellaria umbellata
Symphyorichum ciliatum (*Aster brachyactis*)
Symphyorichum yukonense (*Aster yukonensis*)
Taraxacum lyratum
Typha latifolia
Triantha glutinosa
Utricularia minor
Valeriana sitchensis
Veronica americana
Viola adunca

Range Extensions of Introduced Taxa within the Yukon Territory (8):

Alopecurus geniculatus
Alopecurus pratensis
Avena sativa
Phalaris arundinacea
Polygonum convolvulus
Psathyrostachys juncea
Secale cereale
Vicia americana

Comments on Native Taxa in the Yukon Flora (2):

Lonicera involucrata
Saxifraga nelsoniana ssp. *carlottae*

Deletions of Native Taxa from the Yukon Flora (4):

Clematis occidentalis
Lonicera involucrata
Polygonum persicaria
Verbena hastata

LYCOPODIACEAE

Lycopodium sitchense Rupr. (*L. sabinifolium* Willd. ssp. *sitchense* (Rupr.) Calder & Taylor, *Diphasiastrum sitchense* (Rupr.) Holub), Sitka Club-moss – YUKON: Kluane National Park, Fisher Glacier near Alsek River, W-facing slope above valley glacier leading into Fisher Glacier, 60°08'16"N 138°13'28"W, *B. A. Bennett 03-983*, 7 July 2003 (DAO); Kluane National Park, Alsek River, ca. 38 km SW of Haines Junction, 1245 m in alpine *Festuca altaica* community, coarse soil, well drained aspect N62E slope 5% 60°28'N 137°52'W, *G. W. Douglas & M. J. Ratcliffe 10779*, 8 July 1978, on mixed sheet with *Diphasiastrum alpinum*, determined by B. A. Bennett, confirmed by A. Ceska. (Specimen housed at the Royal BC Museum V137472).

The map in Hultén (1968) had a dot in the southwest of the Yukon which Cody (1996) considered to be a misidentification. Cody (1996) suggested that it should be looked for in that area and the specimens cited above is a verification.

FIGURE 1. Locator map – Southwest Yukon (courtesy of the Yukon Territorial Government).

PTERIDACEAE

Cryptogramma crispa (L.) R.Br. var. *sitchensis* (Rupr.) C. Christensen, Sitka Parsley Fern. – YUKON: Kluane National Park, Fisher Glacier near Alsek River, W-facing slope above valley glacier leading into Fisher Glacier, mid-slope in large talus, thin soil of silty sand with rock outcrop, 60°08'16"N 138°13'28"W, *B. A. Bennett 03-1000*, 7 July 2003 (DAO); Fisher Glacier near Alsek River, NE of base camp, under boulders in steep unvegetated draws on south-facing slope, 60°08'31"N 138°13'13"W, *B. A. Bennett 03-1069*, 8 July 2003 (DAO).

Douglas et al. (1981) did not include this fern in the Rare Vascular Plants of the Yukon but Cody (1996) knew it from only three sites adjacent to the Canol Road. The specimens cited above are an extension of the known range in the Territory of about 325 kilometers south of a site adjacent to the South Canol Road and are new to Kluane National Park.

ASPIDIACEAE

Athyrium filix-femina (L.) Roth var. *cyclosorum* (Ledeb.) Moore, Lady Fern – YUKON: moist organic soil, meadows in thickets, east Haines Hwy. at Km 152, 60°02.970'N 136°53.001'W, *P. Caswell 03-747*, 21 Aug. 2003 (DAO); Kluane National Park, Fisher Glacier near Alsek, NE of base camp, under boulders in steep unvegetated draws on south-facing slope where it was rare, 60°03'31"N 138°13'W, *B. A. Bennett 03-1062*, 8 July 2003 (DAO).

This species was considered rare in the Territory by Douglas et al. (1981) and Cody (1996). The first specimen cited above is from a site about 60 kilometers east of a site mapped by Cody (1996) in southern Kluane National Park. The second specimen is from a site about 20 kilometers northwest.

Polystichum lonchitis (L.) Roth., Holly Fern – YUKON: Kluane National Park, Fisher Glacier near Alsek River, NE of base camp, under boulders in steep unvegetated draws on south-facing slope, where it was rare, 60°08'31"N 138°13'13"W, *B. A. Bennett 03-1061*, 8 July 2003 (DAO).

This species was considered rare in the Yukon by Douglas et al. (1981) and Cody (1996) where it was only known from two widely separated localities. The specimen cited above is an extension of about 30 kilometers northwest of a previously known site in Kluane National Park adjacent to the British Columbia border.

PINACEAE

Pinus contorta Dougl. ex Loud. ssp. *latifolia* (Engelm.) Critchfield, Lodgepole Pine – YUKON: open slope west of the road, only single large old tree at least 10 m tall; appears to pre-date the construction of the highway,

appearing natural, Haines Road Km 157, south of Million Dollar Falls, 60°05'27"N 136°55'01", *B. A. Bennett 03-003*, 27 April 2003 (DAO).

The specimen cited above is the southernmost yet found in the southwest of the Territory. It is from a site about 30 kilometers south-southeast of a site reported by Cody et al. (2003) adjacent to the St. Elias Trail in Kluane National Park.

TYPHACEAE

Typha latifolia L., Common Cattail – YUKON: extensively placer mined area, Lower Hunker Creek area east of Dawson City, 64°01'N 139°03'01.2"W, *G. Brunner 594*, 7 Sept. 2003 (DAO); Gravel around and in small pond with scattered *Salix*, *Carex*, and *Schoenoplectus*, up Hunker Creek Road east of Dawson Creek, 64°01'11.9"N 139°08'57.8"W, *Peterson 18518, Saarela and Smith*, 11 July 2004 (DAO).

The specimen cited above is an extension of the known range of this rare species in the Territory of about 175 kilometers northwest of Mayo.

POTAMOGETONACEAE

Potamogeton praelongus Wulf., White-stemmed Pondweed – YUKON: floating on surface of lake, Pine Lake, 60°43.015'N 137°28.287'W, *P. Caswell 03-491*, 23 July 2003 (DAO).

Douglas et al. (1981) considered this taxon rare in the Territory. The specimen cited above is an extension of the known range of about 60 kilometers north of a site reported by Cody et al. (2000).

NAJADACEAE

Najas flexilis (Willd.) Rostk. & Schmidt, Wavy Water Nymph (Figure 2) – YUKON: meso-eutrophic lake and mesotrophic mire, west side of Wye Lake, Watson Lake, 60°07'N 128°48'W, *R. Elven & H. Solstad 03-1301*, 29 Aug. 2003 (DAO).

This is a new species in the flora of the Yukon Territory which should be added to the list of rare plants (Douglas et al. 1981). Najadaceae can be separated from Potamogetonaceae as follows:

A. Flowers solitary in the leaf axils; leaf margins minutely serrulate with 35-80 teeth per side ..... *Najadaceae*

A. Flowers born on spikes or racemes; leaf margins entire ..... *Potamogetonaceae*

Najas flexilis can be described as follows: Submerged, annual monoecious, slender-stemmed, bushy or elongate, and often forming extensive beds; leaves numerous, becoming more crowded toward the branch tips, narrow, 1-3 cm long, mostly less than 1 mm wide, gradually tapering to a sharp point, minutely toothed; flowers unisexual, born in the axils of the branches and from the sheaths of leaf-bases; anthers 1-celled; pistils mostly with 3 stigmas; fruit and seed narrowly ovoid or elliptic, 2-3 mm long; seed entirely filling the fruit, shiny, reddish-brown.

In Canada, this species is known from Newfoundland to British Columbia; the nearest known site to that cited above is in Wood Buffalo Park just south of Fort Smith (Porsild and Cody 1980).

POACEAE

Agrostis humilis Vasey, (*Agrostis thurberiana* Hitchc., *Podagrostis thurberiana* (Hitchc.) Hultén), Alpine Bentgrass (Figure 3) – YUKON: Kluane National Park, rare in open herbaceous and graminoid meadows of south-facing mid-slopes in drier patches of open soil, Fisher Glacier near Alsek River, NE of base camp, 60°03'31"N 138°13'13"W, *B. A. Bennett 03-1073*, 8 July 2003, (DAO); Kluane National Park, Shursho Lake, meadow near lake, 100% vegetative coverage, moist organic soil, 60°03.6'N 137°23.8'W, *P. Caswell & R. Maraj 04-427*, 4 August 2004 (DAO) (determined by S. J. Darbyshire).

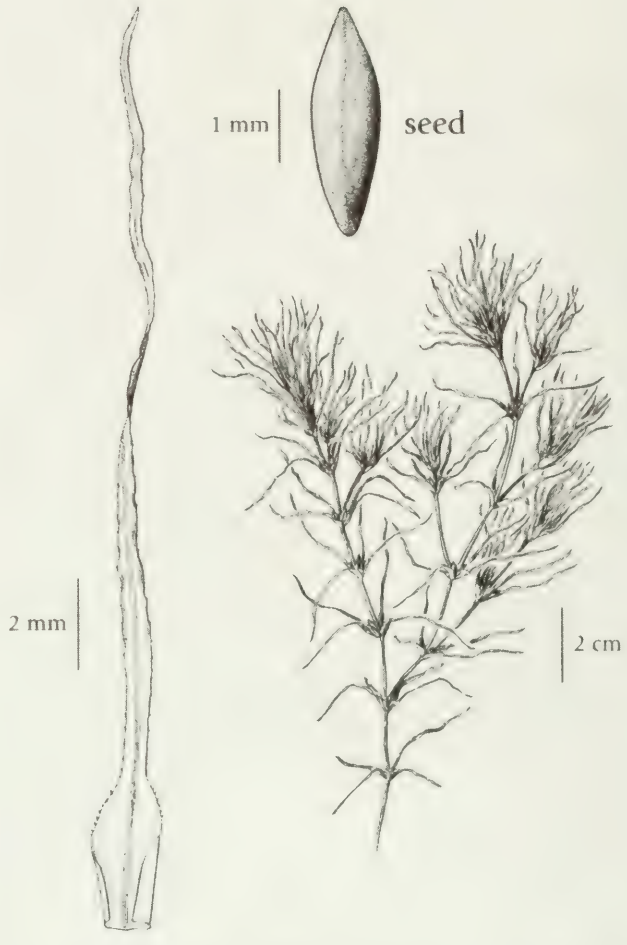

FIGURE 2. *Najas flexilis* (Willd.) Rostk. & Schmidt, Wavy Water Nymph (illustration by J. R. Janish courtesy of the University of Washington Press).

Agrostis humilis can be described as follows: Perennial tufted or matted grass from fibrous roots; stems 5-30 cm tall; leaves about 2.5 mm broad, panicle narrow; spikelets about 2 mm long, violet; lemmas 1.5-2.3 mm long, awnless; rachilla minutely pubescent; paleas present, at least half as long as the lemmas, anthers about (0.5) 06-0.8 mm long.

This species is new to the flora of the Yukon Territory and should be added to the list of rare plants in the Territory. It is frequent in the subalpine and alpine zones throughout British Columbia, and extends into southern Alberta and south to California, Nevada, Utah and New Mexico. *Agrostis gigantea* and *A. capillaris* are rhizomatous; however, *A. humilis* is caespitose, so is more closely related to A. *scabra* and *A. exarata*. It can be separated from *Agrostis scabra* and *Agrostis exarata* as follows:

A. Paleas present, at least half as long as lemmas ..... *A. humilis*

A. Paleas absent or less than half as long as lemmas ..... *A. scabra* and *A. exarata*

Alopecurus geniculatus L., Water Meadow-foxtail – YUKON: Fort Selkirk, 62°47'N 137°23'W, *J. B. Tarleton*, Summer 1899 (US).

This species, which is introduced in Canada from Eurasia, was reported as new to the Territory (Cody et al. 2003) from Horseshoe Slough. It is common in SW British Columbia north to the Queen Charlotte Islands. The above collection was reported by Britton and Rydberg (1901) and is a range extension of 130 km to the southwest.

Alopecurus pratensis L., Meadow Foxtail – YUKON: uncommon in moist areas between fence and highway, Takhini Salt Flats, 60°51'23"N 135°42'55"W, *B. A. Bennett, R. Elven & H. Solstad 03-086*, 26 Aug. 2003 (B. A. Bennett Herbarium, photo DAO).

This is an introduced species that is not yet common in the Territory. The nearest known site to that listed above is about 60 kilometers south of Whitehorse.

Avena sativa L., Oats – YUKON: moist, gritty organic soil, Alaska Hwy., about 30 kilometers northwest of Haines Junction in squirrel research area, 60°57.110'N 138°02.388'W, *P. Caswell 03-563*, 8 Aug. 2003 (DAO).

Cody (1996) knew this introduced species from only three sites in the Territory (the vicinity of Mayo, North Canol Road and east of Watson Lake). An additional site was found by Cody in the vicinity of Whitehorse (Cody et al. 2004).

Bromus japonicus Thunb. ex Murray, Japanese Brome (Figure 4) – YUKON: highway embankment, Alaska Hwy. at Jarvis River Bridge, 60°55.349'N 137°53.060'W, *P. Caswell 03-555*, 8 Aug. 2003 (DAO) (determined by S. J. Darbyshire).

The specimen cited above is a new introduction to the Yukon Territory but is not known to persist. It could not be found at this location in 2004. It is known across Canada from Quebec to southern British Columbia from dry fields and waste places.

Bromus japonicus can be described as follows: Annual, from fibrous roots. Culms (20-) 30-70 cm tall, erect or ascending; sheaths mostly very densely pilose to lanate, the upper ones sometimes pubescent to glabrous; ligules hairy; sheaths densely haired; blades 10-20 cm long, mostly softly pilose on both sides; panicle 10-17 (-22) cm long, diffuse nodding, with spreading to ascending, to somewhat drooping, slender, flexuous branchlets that are mostly longer than the spikelets; spikelets 6-12 flowered, glumes glabrous to scabrous, lanceolate, the lower one 3-nerved 4-6 mm long, the upper 5-nerved 6-8.5 mm long; anthers included in the lemmas 1-1.5 mm long. It can be separated from *Bromus hordeaceus* as follows:

A. Panicle dense or narrow, usually erect; panicle branchlets and pedicels shorter than spikelets ..... *B. hordeaceus*

A. Panicle nodding or erect, mostly open; panicle branches and pedicels as long as or longer than spikelets ..... *B. japonicus*

Festuca brachyphylla Schultes & Schultes f., Alpine Fescue – YUKON: Kluane National Park, nunatak between Lowell and Dusty Glaciers near Ulu Mountain, 60°21'32"N 138°34'49"W, *B. A. Bennett 03-948*, 6 July 2003 (DAO) (determined by S. J. Darbyshire).

FIGURE 3. *Agrostis humilis* Vasey, Mountain Bent Grass (from Vasey, 1893. Grasses of the Pacific Slope)

The specimen cited above is an extension of the known range in the Park of about 50 kilometers south of a site mapped by Cody (1996).

Festuca brevissima Jurtz., Alaska Fescue – YUKON: Kluane National Park, loose rocks with some organic soil on rocky slope, Kings Throne Trail, 60°33.476'N 139°14.282'W, *P. Caswell 02-125*, 21 June 2002 (DAO).

The specimen cited above of this Amphi-Beringian species is an extension of the known range in the Territory of about 350 kilometers south of a site about latitude 63°40'N. It is new to the flora of Kluane National Park.

Festuca minutiflora Rydb., Little Fescue – YUKON: Kluane National Park, loose soil with organic component at entrance of Arctic Ground Squirrel burrow, hill overlooking Ogilvie Glacier at termination of stream flowing south of Warden Cabin, nunatak at Logan Warden Cabin, 60°47.652'N 140°46.303'W, *P. Caswell et al. 03-334*, 12 July 2003 (DAO).

The specimen cited above is the westernmost yet found in Kluane National Park and is an extension of the known range in the Park of about 100 kilometers to the west of a site mapped by Cody (1996).

Leymus mollis (Trin.) Pilger ssp. *mollis* s.l., American Lyme Grass – YUKON: roadside gravel, Takhini Hotsprings Road about 1 km east of hotsprings, one

patch only – introduced, 60°50'30"N 135°20'30"W, *B. A. Bennett, R. Elven & H. Solstad 03-1300*, 26 Aug. 2003 (DAO).

Cody (1996) knew ssp. *villosissimus* (Scribn.) A. Löve from adjacent to the Arctic coast. The specimen cited above is the first record of this variable subspecies from the interior and southern part of the Territory.

Phalaris arundinacea L., Reed Canary Grass – YUKON: 3 km west of White River along Alaska Highway on north side of road; appears to be seeded, 61°59'N 140°30'10"W, *B. A. Bennett 04-0002*, 10 April 2004 (DAO).

The specimen cited above is from a site about 225 kilometers northwest of a site southwest of Haines Junction in Kluane National Park cited by Cody et al. (2003) where it was native and a site about 175 kilometers to the northeast by Mechanic Creek where it was introduced (Cody et al. 2001).

Phippsia algida (Sol.) R.Br., Ice Grass – YUKON: Kluane National Park; dried and cracked mud at edge of large pond near Warden Cabin, nunatuk at Logan Warden Cabin, 60°47.628'N 140°45.148'W, *P. Caswell et al. 03-216*, 11 July 2003 (DAO).

The specimen cited above, which is the most southwesterly yet found in the Territory, is from a site about 115 kilometers southwest of a site mapped by Cody (1996) near the south end of Kluane Lake.

Psathyrostachys juncea (Fisch.) Nevski (*Elymus junceus* Fisch.) Russian Wild Rye – YUKON: roadside at milepost 812, Alaska Highway, *S. E. Welsh & G. Moore 7635*, 2 July 1968 (University of Alaska Herbarium, photo DAO) (determined by M. Barkworth). Stanley Welsh (1974) reported the specimen cited above and another one collected by M. V. Guttman collected from adjacent to Mile 1019 Alaska Hwy. on 25 July 1960 (ISC). These records were unfortunately missed when writing the *Yukon Flora* (Cody 1996, 2000).

This introduced species was first reported and described by Cody et al. (2003) sub. *Elymus junceus* from Dezadeash Lake adjacent to Km 195 Haines Hwy.

Secale cereale L., Rye – YUKON: disturbed sandy soil, Whitehorse, between Mt. McIntyre Recreation Centre and Aquatic Centre Parking Lot, 60°03.32'N 135°43.49'W, *B. A. Bennett 03-1369*, 8 Oct. 2003 (B. A. Bennett Herbarium, photo DAO).

This introduced species was first collected by J. M. Gillett in gravel areas near warehouses in Watson Lake in 1949. The specimen cited above is only the second found growing wild in the Territory.

CYPERACEAE

Blysmopsis rufa (Huds.) Oteng-Yeboah (*Scirpus rufus* (Huds.) Schrad., *Blysmus rufus* (Huds.) Link), Red Bulrush, Swaying Rush (Figure 5) – YUKON: alkaline lake, saline flat 600 m south of Fox Creek, on east side of North Klondike Hwy., Km 227, 61°05.477'N 135°16.826'W, *R. Elven & H. Solstad 03-1305*, 25 Sept. 2003 (B. A. Bennett Herbarium, photo DAO).

FIGURE 4. *Bromus japonicus* (Willd.) Rostk. & Schmidt, Wavy Water Nymph (Japanese Brome) (illustration by J. R. Janish courtesy of the University of Washington Press).

This is a new species to the flora of the Yukon Territory which should be added to the list of rare plants (Douglas et al. 1981). To the east it is rare in the former District of Mackenzie from a saline meadow adjacent to the Keele River in the Mackenzie Mountains and on saline river banks near Wrigley in the Mackenzie Valley and to the west from tidal flats in the Matanuska area. It can be separated from *Schoenplectus tabernaemontani* (*Scirpus validus*) as follows:

A. Spikelets several, 2-ranked, in a terminal spike; perianth bristles lacking, inflorescence flattened ..... *Blysmopsis rufa* (*Scirpus rufus*)

A. Spikelets solitary or few to numerous, not 2-ranked, in compact to open umbels or panicles; inflorescences not flattened ..... *Schoenplectus tabernaemontani* (*Scirpus validus*)

Blysmopsis rufa (*Scirpus rufus*) can be described as: Perennial, loosely caespitose with horizontal rhizomes 1-3 mm thick; culms (5-) 10-45 cm × 1-2 (3) mm, glabrous; leaves 1-3; blades 2-12 (-18) cm × 1.5-4 mm, midrib inconspicuous, apex blunt, glabrous; inflorescence in loose spikes, 5-8 spikelets distichous, spreading-ascending; bracts erect to oblique, leaflike or scalelike, 4-15 mm; perianth bristles separating from achene when mature; style as long as stigma.

Carex bebbii (L. H. Bailey) Olney ex Fern., Bebb's Sedge (Figure 6) – YUKON: on old road to wetland west of bridge, north of road, La Biche River, 60°05.74'N 124°01.98'W, *B. A. Bennett 98-634*, 15 June 1998 (DAO) (determined by A. A. Reznicek).

This species is new to the flora of the Yukon Territory and should be added to the list of rare species (Douglas et al. 1981). In the present key *Carex bebbii* would key out as *C. crawfordii*, but can be distinguished from that species using the following characters:

A. Perigynia subulate to narrowly ovate-lanceolate, 3-4 times as long as wide, thin and scale-like ..... *C. crawfordii*

A. Perigynia narrowly to broadly ovate, at most twice as long as wide, membranous ..... *C. bebbii*

Carex brunnescens (Pers.) Poir., Brownish Sedge – YUKON: Kluane National Park, very wet, muddy soil at base of beaver dam, trail between Mush Lake and Bates Lake, 60°18.047'N 137°31.560'W, *P. Caswell 03-699*, 30 July 2003 (DAO).

The specimen cited above is an extension of the known range in the Park of about 40 kilometers south of a site at 60°42'N 137°27'W reported by Cody et al. (2003). These two sites are about 200 kilometers west of a site adjacent to Jake's Corner (Cody 1996).

Carex buxbaumii Wahlenb., Buxbaum's Sedge – YUKON: bog with tussocks at edge of Haines Hwy., 60°08.570'N 136°58.469'W, *P. Caswell 02-454*, 13 July 2002 (DAO); Kluane National Park, bank of shady streamlet shaded by willows, Auriol Trail, 64°44'15"N 137°30'40"W, *P. Caswell 02-662*, 7 Aug. 2002 (DAO); growing in edge of small thermokarst pond southwest of highway, Alaska Hwy., 6 km northwest of Dry Creek #2, 62°13.455'N 140°41.544'W, *B. A. Bennett, R. Elven & H. Solstad 03-087*, 8 Aug. 2003 (DAO).

FIGURE 5. *Blysmopsis rufa* (Huds.) Oteng-Yeboah, Red Bulrush (drawn by Lee Mennell).

This species was not included in the rare plants of the Territory (Douglas et al. 1981) because it is widespread circumpolar. The first specimen cited above is from a site about 125 kilometers southwest of Whitehorse. The second specimen is from a site just southwest of Haines Junction and is the second record for Kluane National Park. The third specimen is an extension of about 120 kilometers northwest of a site north of Kluane Lake.

Carex canescens L., Grey Sedge – YUKON: Kluane National Park, Cyclops Lake, about 10 km NE of Mush Lake, 60°21'20"N 137°11'30"W, *R. D. Wickstrom 276*, 21 July 1974 (DAO); gravel with some organic soil, base of highway embankment, streamlet west of Alaska Hwy. near Rock Glacier, 60°25.0'N 137°02.5'W, *P. Caswell 02-654*, 5 Aug. 2002 (DAO).

This species is widespread throughout much of the Yukon Territory. The specimens cited above are new to Kluane National Park. The nearest site known to Cody (1996) is south of Whitehorse, about 125 kilometers to the east.

Carex eburnea Boott, Bristle-leaved Sedge – YUKON: growing in crevice of rockface, steep scree slope, old burn, Beaver River, 60°24'44"N 125°48'05"W, *B. A. Bennett 97-456*, 14 Aug. 1997 (DAO); dry scree below outcrop, Beaver River Camp #1, 60°30'40"N 126°06'26"W, *B. A. Bennett 97-417*, 13 Aug. 1997 (DAO); raven nest site, riverbar, base of cliff, Wind River, 65°12.49'N 135°13.17'W, *B. A. Bennett 00-369*, 5 July 2000 (DAO); silty seep on edge of river, Peel River Site #1, 65°58.06'N 134°49.69'W, *B. A. Bennett 00-433*, 10 July 2000 (DAO) (determined by A. A. Reznicek); in floodplain tall closed balsam poplar, White River, 63°07.01'N 140°23.27'W, *R. Rosie s.n.*, 26 Aug. 2002 (B. A. Bennett Herbarium, photo DAO); Dempster Highway, Windy Pass, Km 160, flat floodplain with *Leymus innovatus* in sandy calcareous soil, *Bennett & Mulder 03-1307*, 30 Aug. 2003 (DAO).

Douglas et al. (1981) knew this rare species in the Territory from a single collection in the Koidern area in the extreme west just south of latitude 62°N. The first four specimens cited above which were originally determined as *Carex capillaris* and *C. williamsii* extend the known range to the extreme southeast and northeast to the Wind and Peel rivers. The additional two specimens extend the known range westward to the Dempster Highway and White River.

Carex lasiocarpa Ehrh., Slender Sedge – YUKON: flooded shoreline, Blind Lake, 60°05'0.5"N 128° 14'49.7"W, *J. Staniforth 6*, 26-28 June 2003 (DAO) (determined by P. M. Catling); small pond near highway northwest of bridge, mineralized soil, northwest side of Donjek River, 61°40.8'N 139°45.58'W, *B. A. Bennett, R. Elven & H. Solstad 03-056*, 8 Aug. 2003 (DAO).

This species was considered rare in the Territory (Douglas et al. 1981) on the basis of a collection from the Elsa area. An additional site was mapped in the southwest by Cody (1996). Cody et al. (1998, 2002) reported new sites in the southeast from the vicinities of Watson Lake and Frances Lake. The first specimen cited above is an extension of the known range of about 30 kilometers east of Watson Lake. The second specimen is an extension of the known range of

FIGURE 6. *Carex bebbii* (L.H. Bailey) Olney ex Fern., Bebb's Sedge (illustration by J. R. Janish courtesy of the University of Washington Press).

about 60 kilometers north of a site in northern Kluane National Park.

Carex laxa Wahlenb., Weak Sedge – YUKON: edge of small thermokarst pond southwest of Alaska Highway 6 kilometers northwest of Dry Creek, 62°13.455'N 140°41.544'W, *B. A. Bennett, R. Elven & H. Solstad 03-042*, 8 Aug. 2003 (Yukon Government Herbarium, photo DAO).

This Amphi-Beringian species was previously known in North America from two stations in Alaska, one in the Mackenzie Delta, and two localities in Central Yukon where it was considered rare by Douglas et al. (1981) [Cody 1996]. The specimen cited above is from a site about 300 kilometers southwest of sites in the vicinities of Mayo and Elsa.

Carex lenticularis Michaux var. *dolia* (M. E. Jones) L. A. Standley (*C. enanderi* Hultén), Enander's Sedge – YUKON: Kluane National Park, rare, seen only along creek near camp, Fisher Glacier near Alsek River, base camp, 60°08'31"N 138°13'13"W, *B. A. Bennett 03-955*, 6 July 2003 (DAO) (determined by Ph.D. candidate Julie A. Dragon from the University of Vermont).

First reported from Yukon by Standley et al. (2002) this is a new variety in the Yukon Territory and should be added to the *Rare Vascular Plants of the Yukon* (Douglas et al. 1981). It can be separated from *Carex lenticularis* var. *lenticularis* as follows (from *Flora of North America* Volume 23):

A. Terminal spike gynecandrous (with pistillate flowers at the apex); proximal spike not exceeding 1.5 cm; peduncle less than 1 cm; perigynia ovoid ..... var. *dolia*

A. Terminal spike usually staminate; proximal spike longer than 1.5 cm; peduncle 1 cm or longer; perigynia ovoid to ellipsoid ..... var. *lenticularis*

Carex eleusinoides is similar in inflorescence morphology, but may be distinguished by its red basal sheaths and short, veinless perigynia.

This species was considered rare in the Territory by Douglas et al. (1981). The specimen cited above, which is very reduced in size, is new to Kluane National Park and is from a site about 140 kilometers south of a site at the north end of Kluane Lake.

Carex lenticularis Michx. var. *lipocarpa* (Holm) L. A. Standley, Kellogg's Sedge – YUKON: Kluane National Park, braided river bed in muddy area toward a small pond, Plug Creek, 60°03.593'N 138°12.055'W, *P. Caswell et al. 03-672*, 29 July 2003 (DAO).

Cody (1996) suggested that this sedge should be looked for in southern Yukon Territory because Hultén (1968) indicated collection sites from just north of where the British Columbia specimens were found. Bruce A. Bennett found it in a *Sphagnum* bog southeast of Watson Lake in 1996 (Cody et al. 1998). This record was overlooked by Standley et al. (2002). The specimen cited above is only the second yet confirmed and is from a site about 500 kilometers to the west.

Carex livida (Wahl.) Willd., Pale Sedge – YUKON: southwest of highway, growing in edge of small thermokarst pond, Alaska Hwy., 6 km NW of Dry Creek #2, 62°13.455'N 140°41.555'W, *B. A. Bennett 03-043*, 8 Aug. 2003 (DAO); moist organic soil, bog east of Haines Hwy., 60°08.421'N 136°58.499'W, *P. Caswell 02-448*, 13 July 2002 (DAO).

FIGURE 7. *Carex nigricans* C.A. Mey., Blackish Sedge. (illustration by J. R. Janish courtesy of the University of Washington Press).

This circumpolar species with large gaps in its range was considered rare in the Territory by Douglas et al. (1981). The first specimen cited above is an extension of the known range in the Territory of about 160 kilometers west of a site southwest of Carmacks. The second specimen is from a site about 200 kilometers south of the site southwest of Carmacks.

Carex microglochin Wahl., Few-seeded Fen Sedge – YUKON: moist organic soil in bog east of Haines Hwy., 60°08.421'N 136°59.499'W, *P. Caswell 02-452B*, 13 July 2002 (DAO).

This circumpolar species was known to Cody (1996) from four widely separated areas in the Territory. The specimen cited above is from a site about 85 kilometers southeast of a site in Kluane National Park just southwest of Haines Junction.

Carex microptera Mack., Small-winged Sedge – YUKON: wet lakeshore, Inlet of Caribou Creek to Caribou Lake, 60°32.0'N 134°15.9'W, *S. Withers SW00-168*, 7 Aug. 2000 (DAO).

This collection originally identified as *Carex pachystachya* (Cody et al. 2003) was reidentified by A. A. Reznicek. Douglas et al. (1981) did not consider this species rare in the

Territory because it is widespread in western North America. Cody (1996) knew it from only nine sites in the southern part of the Territory. The specimen cited above is from a site intermediate between the vicinities of Whitehorse and Johnson's Crossing.

Carex nardina Fries, Spikehead Sedge – YUKON: Kluane National Park, nunatak near Ulu Mountain, 60°21'32"N 138°34'49"W, *B. A. Bennett 03-929*, 6 July 2003 (DAO).

The specimen cited above is an extension of the known range in the Park of about 35 kilometers southwest of the most southeasterly site in the Park mapped by Cody (1996).

Carex nigricans C. A. Mey., Blackish Sedge (Figure 7) – YUKON: Kluane National Park, uncommon, seen along creek near camp and muddy flats upstream, Fisher Glacier near Alsek River, base camp, 60°08'31"N 138°13'13"W, *B. A. Bennett 03-954*, 6 July 2003 (DAO); 300 m east of camp, flat moist tundra at bottom of broad valley with *Diphasiastrum alpinum*, *Juncus drummondii*, Fisher Glacier near Alsek River, 60°08'31"N 138°13'13"W, *B. A. Bennett 03-1074*, 8 July 2003 (DAO).

This is a new species in the Yukon Territory and should be added to *The Rare Vascular Plants of the Yukon* (Douglas et al. 1981). *Carex nigricans* can be described as: plants loosely caespitose, mat-forming; rhizomes short, stout; culms 5-30 cm; leaves flat to the tip, 2-4 mm wide; pistillate scales reddish brown to black, lanceolate, as broad as long and as long as or slightly longer than perigynia, margins not hyaline or scarious, apex acute to acuminate; perigynia 3.8-4.1 × 1-1.2 mm; beak dark brown to black, frequently as long as body of perigynium; stigmas 3. It can be separated from *Carex pyrenaica* as follows:

A. Plants rhizomatous; leaves 1.5-2 mm broad, flat or channelled basally; staminate flowers occupying one-third to one-half of the spike ..... *C. nigricans*
A. Plants clump-forming; leaves 1.5 mm broad or less, channelled throughout; staminate flowers occupying less than one-third of the spike ..... *C. pyrenaica*

Carex parryana Dewey, Parry's Sedge – YUKON: silty broad alkaline river flat, northwest side of Donjek River, 61°40.8'N 139°45.58'W, *B. A. Bennett, R. Elven & H. Solstad 03-054*, 8 Aug. 2003 (DAO).

The specimen cited above is an extension of the known range in the Territory (Cody 1996) of about 125 kilometers northwest of a site in the vicinity of Kluane Lake.

Carex phaeocephala Piper, Dunhead Sedge – YUKON: Kluane National Park, west-facing slope, drier soils in herbaceous meadow dominated by *Luetkea pectinata*, Fisher Glacier near Alsek River, 60°08'09"N 138°13'10"W, *B. A. Bennett 03-986*, 7 July 2003 (DAO); common open herbaceous and graminoid meadow of south-facing mid-slopes in drier patches of open soil, northeast of base camp, Fisher Glacier near Alsek River, 60°08'31"N 138°13'13"W, *B. A. Bennett 03-1065*, 8 July 2003 (DAO) (determined by A. A. Reznicek); south-facing slope, thin coarse soil surrounded by boulders and ice, nunatak between Lowell and Dusty glaciers near Ulu Mountain, 60°21'32"N 138°34'49"W, *B. A. Bennett 03-930*, 6 July 2003 (DAO) (determined by A. A. Reznicek).

Douglas et al. (1981) knew this rare species in the Territory only from Kluane National Park. The first two specimens cited above are an extension of about 70 kilometers west of a site adjacent to the Haines Hwy. mapped by Cody (1996) and the third specimen is about 40 kilometers further to the northwest.

Carex sartwellii Dewey, Sartwell's Sedge (Figure 8) – YUKON: occasional in alkaline area in grassy openings on dwarf birch-willow flats at 2500', Mile 26 on road from Whitehorse to Dawson, 61°08'N 135°21'W, *J. A. Calder and I. Kukkonen 28035*, 9 Aug. 1960 (DAO) (determined by A. A. Reznicek).

This is a new species to be found in the Yukon Territory and should be added to the list of rare species (Douglas et al. 1981). It can be separated from *Carex praegracilis* as follows:

A. Upper sheaths translucent below; perigynia with beaks not sharply bidentate, not thin – margined above ..... *C. praegracilis*
A. Upper sheaths green-lined below; perigynia with beaks sharply bidentate, thin margined above ..... *C. sartwellii*

In Canada this species is known from south-central and southeastern British Columbia north to southern part of the former District of Mackenzie and east to Quebec. *Carex sartwellii* can be described as follows: Perennial herb from stout, creeping, scaly, fibre-covered rhizomes; stems 30-80 cm tall arising singly or a few together, longer than the leaves; sheaths tight, brown, glabrous, inner band green; blades 2-4 per stem 2.5-5 mm wide, lower ones reduced to scales; spikes 20 or more nearly cylindrical, except near the apex; basal spikes more prominent than middle spikes; perigynia (2.3-) 2.8-4 × 1.3-2 mm; achenes brown, smooth 1.2-2 mm long, stigmas 2.

Carex siccata Dewey, Hay Sedge – YUKON: *Picea mariana* dominated forest, Beaver River near Larsen Airstrip, 60°10'42"N 125°05'38"W, *B. A. Bennett 95314*, 22 June 1995 (B. A. Bennett Herbarium, photo DAO) (determined by A. A. Reznicek).

The specimen cited above was originally identified as *Carex foenea* (Cody et al. 1998) and all of the three specimens mapped previously (Cody 1996) are presumably referable to this species. The name *Carex foenea* correctly refers to a species in section Ovales (*C. aenea*), but has frequently been misapplied to this species. *Carex foenea* (= *C. aenea* of Cody 1996) is widespread in southern Yukon. The name *Carex siccata* was first applied to Yukon plants by Reznicek (2002). *Carex foenea* and *C. siccata* can be separated as follows:

A. Plants caespitose; spikes 3-7 (-11); perigynia with wing 0.2-0.4 mm wide ... *Carex foenea*
A. Plant with long creeping rhizomes; spikes 4-12; perigynia wingless ..... *Carex siccata*

Eriophorum gracile Koch, Slender Cotton-grass – YUKON: flooded shoreline, Blind Lake, 60°05'0.5"N 128°14'49.7"W, *J. Staniforth 3*, 26-28 June 2003 (DAO).

Cody (1994) reported the first specimen known from the Territory from a site near the British Columbia border between longitudes 127°W and 128°W and recommended that this species should be added to the list of rare vascular plants of the Yukon Territory (Douglas et al. 1981). Additional specimens have since been reported from Upper Coal River and Frances Lake (Cody et al. 1998) and Turner Lake (Cody et al. 2001). The specimen cited above is from a site about half way between the first known site and Watson Lake.

Schoenoplectus acutus (Muhl. ex Bigelow) A. & D. Löve var. *acutus*) (*Scirpus acutus* Muhl. ex Bigelow), Hard-stemmed Bulrush – YUKON: aquatic emergent, Blind Lake, 60°06'7.9"N 128°13'1.6"W, *J. Staniforth 7*, 26-28 June 2003 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 300 kilometers southeast of sites in the vicinity of Ross River (Cody et al. 2001).

Schoenoplectus tabernaemontani (C.C. Gmel.) Palla (*Scirpus validus* Vahl), Soft-stem Club-rush – YUKON: extensively placer mined area, Lower Hunker Creek area east of Dawson City, 64°01'14.2"N 139°09'01.2"W, *G. Brunner 593*, 7 Sept. 2003 (DAO).

The specimen cited above is from a site about 150 kilometers south of a site adjacent to the Dempster Hwy. and about 175 kilometers northwest of a site in the vicinity of Mayo.

Trichophorum alpinum (L.) Pers. (*Scirpus hudsonianus* (Michx.) Fern.), Hudson Bay Clubrush – YUKON: growing in edge of small thermokarst pond southwest of Alaska Hwy., 6 km NW of Dry Creek #2, 62°13.455'N 140°41.544'W, *B. A. Bennett, R. Elven & H. Solstad 03-044*, 8 Aug. 2003 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 50 kilometers to the northwest of a site adjacent to the Alaska Hwy. mapped by Cody (1996).

JUNCACEAE

Juncus bufonius L. s.l., Toad Rush – YUKON: in shallows of northeast shore with *Callitriche* and *Eleocharis*, Hidden Lakes, Whitehorse, 60°41.9'N 135°00.6'W, *B. A. Bennett 03-070*, 13 Aug. 2003 (DAO); Kluane National Park, packed moist sand with small rocks and organic component, strip in middle of road, Alsek Trail, 60°46.042'N 137°44.657'W, *P. Caswell 03-755*, 25 Aug. 2003 (DAO).

The first specimen cited above is from a site in the southern part of the Territory between sites in the vicinities of Haines Junction and east of South Canol Road. The second specimen is an extension of the known range in the Territory of about 250 kilometers southwest of a site south of Mayo mapped by Cody (1996).

Juncus filiformis L., Thread Rush – YUKON: Kluane National Park, wet, muddy soil, small marsh at lakeshore, west end of Mush Lake, 60°18.377'N 137° 32.681'W, *P. Caswell 03-687*, 30 July 2003 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 85 kilometers southwest of a site adjacent to the Alaska Hwy. east of Haines Junction

FIGURE 8. *Carex sartwellii* Dewey, Sartwell's Sedge. (illustration by J. R. Janish courtesy of the University of Washington Press).

reported by Cody et al. (2004). It is new to Kluane National Park.

Luzula piperi (Cov.) M. E. Jones, Piper's Wood-rush – YUKON: Kluane National Park, uncommon in herbaceous meadows, usually on the toe of slopes, Fisher Glacier near Alsek River, base camp, 60°08'31"N 138°13'13"W, *B. A. Bennett 03-972*, 6 July 2003 (DAO).

The specimen cited above is only the third known to Cody (1996) in Kluane National Park. It is an extension of the known range to the southwest of about 40 kilometers.

Luzula spicata (L.) DC., Spiked Wood-rush – YUKON: Kluane National Park, W-facing slope above valley

glacier leading into Fisher Glacier near Alsek River, 60°08'25"N 138°13'20"W, *B. A. Bennett 03-1016*, 7 July 2003 (DAO).

The specimen cited above is the southernmost yet found in the Park. It is about 40 kilometers south-southwest of a site southwest of Haines Junction.

LILIACEAE

Triantha glutinosa (Michx.) Baker (*Tofieldia glutinosa* ssp. *brevistyla* sensu Cody (1996)), Sticky False Asphodel – YUKON: silty broad alkaline river on flat, seasonally flooding shore, dominated by *Salix brachycarpa*, *Carex parryana*, *Calamagrostis stricta* and *Aster yukonensis*, northwest side of Donjek River, 61°40.8'N 139°45.58'W, *B. A. Bennett, R. Elven & H. Solstad 03-050*, 8 Aug. 2003 (DAO).

Douglas et al. (1981) considered this taxon as rare in the Territory. The specimen cited above is an extension of the known range of about 230 kilometers northwest of a site in the vicinity of Whitehorse where it was collected by C. E. Kennedy et al. in 1996. The scientific name *Triantha glutinosa* was brought forward by Douglas et al. (2001) and Utech (2002).

IRIDACIAE

Iris setosa Pall. ssp. *interior* (Anders.) Hultén – YUKON: southwest of highway, growing in edge of small thermokarst pond, Alaska Hwy. 6 km NW of Dry Creek #2, 62°13.455'N 140°41.544'W, *B. A. Bennett, R. Elven & H. Solstad 03-048*, 8 Aug. 2003 (B. A. Bennett Herbarium, photo DAO).

This species was considered rare in the Territory by Douglas et al. (1981). The specimen cited above is from a site about 20 kilometers southeast of the Alaska border.

ORCHIDACEAE

Coeloglossum viride (L.) Hartm. ssp. *bracteatum* (Muhl. ex Willd.) Hultén, Bracted Green Orchid – YUKON: moist, black organic soil, edge of road shaded by poplar woods, old road west of Alaska Hwy. (between Kluane Wilderness Camp (Scully's bar) and Donjek River), 61°36.701'N 139°37.730'W, *P. Caswell 02-189*, 25 June 2002 (DAO).

Douglas et al. (1981) considered this species rare in the Territory on the basis of a single collection in the extreme south in the vicinity of Little Atlin Lake. Cody (1996) added a second site from adjacent to the Bonnet Plume River at latitude 65°10'N, and Cody et al. (2001/2002) added two additional sites east and west of the Bonnet Plume River site and a site near the Donjek River. The specimen cited above is an extension of the known range in the Territory of about 13 kilometers southeast of the Donjek River site.

SALICACEAE

Salix niphoclada Rydb. (*S. brachycarpa* Nutt. ssp. *niphoclada* (Rydb.) Argus, Barren-ground Willow – YUKON: Kluane National Park, Fisher Glacier near Alsek River, SW-facing above glacier, 60°08'06"N 138°12'42"W, *B. A. Bennett 03-1027*, 7 July 2003 (DAO) (determined by G. W. Argus).

The specimen cited above is the southernmost yet found in Kluane National Park.

SANTALACEAE

Comandra umbellata (L.) Nutt. ssp. *pallida* (A.DC.) Piehl, Pale Commandra – YUKON: Kluane National Park, open, sage-covered sweeping slope overlooking Slims West Trail and west of the Sheep Bullion Trail, 60°59.138'N 138°35.832'W, *P. Caswell & L. Freese 03-753*, 3 Aug. 2003 (DAO).

The specimen cited above is the first known of this species from Kluane National Park. It was however known to Cody (1996) from adjacent to Kluane Lake on the east side of the Alaska Hwy. Cody (1996) also mapped a site near the Five Finger Rapids adjacent to the Klondike Hwy. southeast of Fort Selkirk (F. Anderson, 18 June 1898, Hultén 1940). It has not been seen again in that area despite some searching. Hultén (1968) and Douglas et al. (1981) accidentally mapped it from the vicinity of Dawson.

POLYGONACEAE

Polygonum achoreum Blake, Striate Knotweed – YUKON: front yard of cabin, Lee's Camp, Beaver River, 60°11'57"N 125°09'42"W, *B. A. Bennett 97-493*, 18 Aug. 1997 (DAO) (determined by M. Costea).

The specimen cited above, originally identified as *P. buxiforme* (Cody et al. 2000), is an extension of the known range in the Territory of about 575 kilometers east of the vicinity of Whitehorse.

Polygonum convolvulus L., Bind-weed, Wild Buckwheat – YUKON: dry, very rich organic soil, abandoned vegetable garden, 14 Willow Acres, Haines Junction, 60°45.823'N 137°29.458'W, *P. Caswell 03-427*, 17 July 2003 (DAO).

Cody (1996) knew this introduced species in the Territory from only four widely separated sites (Whitehorse, Dawson, Carmacks and adjacent to the Campbell Highway northwest of Ross River).

Polygonum lapathifolium L. (*P. pensylvanicum* L. ssp. *oneillii* (Brenckle) Hultén – YUKON: usually submerged in shallow water in marly mud, Ear Lake, Whitehorse, 60°40.81'N 135°02.54'W, *B. A. Bennett 03-035*, 9 Aug. 2003 (DAO); in shallows of northeast shore with *Callitriche verna* and *Eleocharis acicularis*, Hidden Lake, Whitehorse, 60°41.9'N 135°00.6'W, *B. A. Bennett 03-071*, 13 Aug. 2003 (DAO).

Cody et al. (2000) reported this species, which was considered rare in the Territory by Douglas et al. (1981), from three sites about 100 kilometers northwest of the specimens cited above.

Polygonum persicaria L., Lady's-thumb – Cody (1996, 2000) reported the occurrence of this species based on a collection from the Canol Road Mile 55-60 on the east shore of Quiet Lake near Old Road Camp by *A. E. Porsild & A. J. Breitung 11124*, 4 July 1944 (CAN).

This specimen was reviewed by R. Staniforth (1975) who reported that it was possibly *P. lapathifolium*. It was reviewed again by L. L. Consaul (1987) who revised it to *P. lapathifolium*. *P. persicaria* should be deleted from the flora of the Yukon Territory.

Rumex maritimus L. ssp. *fueginus* (Phil.) Hultén, Golden Dock – YUKON: dry, very rich organic soil, abandoned vegetable garden at 14 Willow Acres, Haines Junction, 60°45.823'N 137°29.458'W, *P. Caswell 03-437*, 17 July 2003 (DAO) (determined by S. J. Darbyshire).

The specimen cited above is an extension of about 35 kilometers southeast of a site adjacent to the Alaska Hwy. mapped by Cody (1996).

CARYOPHYLLACEAE

Minuartia dawsonensis (Britt.) House, Bog Sandwort – YUKON: Kluane National Park, packed earth on trail, Alsek Trail past Serpentine Creek, 60°41.397'N 137°46.603'W, *P. Caswell 02-220*, 26 June 2002 (DAO).

The specimen cited above is the first reported from Kluane National Park. It is from a site about 30 kilometers southeast of a site mapped by Cody (1996) adjacent to the Alaska Hwy.

Sagina nivalis (Lindbl.) Fries – YUKON: Kluane National Park, frost heaved mud beside large rocks at edge of lake, shore of pond, south side of large pond in front of Warden Cabin, nunatak at Logan Warden Cabin, 60°47.628'N 140°45.148'W, *P. Caswell et al. 03-356*, 3 July 2003 (DAO).

The specimen cited above is only the second record of the occurrence of this rare species in Kluane National Park where it is about 175 kilometers northwest of the first site (Cody 1996). Douglas et al. (1981) considered this species rare in the Yukon Territory.

Silene acaulis (L.) Jacq. ssp. *subacaulescens* (F.N. Williams) Hultén – YUKON: Kluane National Park, Fisher Glacier near Alsek River, base camp, 60°08'31"N 138°13'13"W, *B. A. Bennett 03-965*, 6 July 2003 (DAO).

The specimen cited above is only the second known from the Park. To the north the nearest sites are just south of latitude 64°N and to the east just east of longitude 133°W (Cody 1996).

Stellaria umbellata Turcz., Umbellate Starwort – YUKON: Buckland Hills, Ivvavik National Park, 69°25'N 139°38'W, *R. Elven 7229-99*, 5 Aug. 1999 (University of Alaska Herbarium, photo DAO) (determined by R. Elven).

This species was considered rare in the Territory by Douglas et al. (1981). Cody (1996) knew it from only three widely separated sites. The specimen cited above is an extension of the known range of about 60 kilometers to the northwest of a site adjacent to the Babbage River.

NYMPHAEACEAE

Nuphar variegatum Engelm., Bullhead Lily – YUKON: pond south of the Alaska Hwy. and west of Donjek River, 61°41'11.8"N 139°47'01.6"W, *D. Normandeau 03-533*, 26 July 2003 (DAO).

This is a rare species in the Territory (Douglas et al. 1981). The specimen cited above is an extension of the known range of about 230 kilometers southwest of a site south of Mayo mapped by Cody (1996).

RANUNCULACEAE

Clematis occidentalis (Hornem.) DC. ssp. *grosseserrata* (Rydb.) Taylor & MacBryde, Purple Clematis – YUKON: Haines Junction, *L. Fournier s.n.*, 13 July 1958 (QFA).

The sample of *Clematis* was revised by B. Boivin in 1965 to *C. tangutica*, with the note: "Note many folioles, more likely to be *C. tangutica*, maybe cultivated." *Clematis tangutica* is a species that has escaped from cultivation and persists in the vicinity of Whitehorse and Carcross (Cody et al. 2001). *Clematis occidentalis* should be deleted from the flora of the Yukon Territory.

PAPAVERACEAE

Papaver radicatum Rottb. ssp. *kluanensis* (D. Löve) D. F. Murray – YUKON: alpine, Friday Creek, 60°25'N 135°14'W, *A. Rhodes 99-537*, 11 Aug. 1999 (B. A. Bennett Herbarium, photo DAO) (determined by R. Elvin and H. Solstad).

The specimen cited above is an extension of about 120 kilometers east of the type site in Kluane National Park (Murray 1995).

BRASSICACEAE

Aphragmus eschscholtzianus Andrz., Eschscholtz' Little Nightmare, Aleutian Cress – YUKON: Kluane National Park, moist, frost sorted rocks and gravel, Wade Mountain, 61°18.594'N 139°30.921'W, *P. Caswell 02-353*, 7 July 2002 (DAO) (determined by G. A. Mulligan).

Douglas et al. (1981) knew this rare species in the Territory from only four sites in the southwest, three of which were in Kluane National Park. The specimen cited above is the fourth in the Park and is from a site about 45 kilometers east of the westernmost site mapped by Cody (1996).

Arabidopsis salsuginea (Pallas) N. Busch (*Thellungiella salsuginea* (Pallas) O. E. Schulz), Saltwater Cress – YUKON: very rich organic soil, abandoned Llama pasture, Haines Junction, 14 Willow Circle, 60°45.816'N 137°29.466'W, *P. Caswell 03-414*, 17 July 2003; same area, 60°45.843'N 137°24.484'W, *P. Caswell 03-055*, 19 June 2003 (DAO) (determined by G. A. Mulligan).

Douglas et al. (1981) and Cody (1996) knew this species from only five sites in the southwest of the Territory. The sixth site cited above is from a location just southeast of the westernmost previously recorded.

Arabis boivinii G. A. Mulligan – YUKON: Kluane National Park, dry sand with organic component, Mush Lake Warden Cabin at west end of Mush Lake, 60°18.496'N 137°32.776'W, *P. Caswell 03-708*, 31 July 2003 (DAO) (determined by G. A. Mulligan).

Cody et al. (2001) reported the first two known sites in the Territory from adjacent to the Haines Hwy. Cody et al. (2003) reported a third site from the old Experimental Farm northwest of Haines Junction. The specimen cited above is the first known from within the borders of Kluane National Park.

Draba albertina Greene, Slender Draba, Alaska Whitlow-grass – YUKON: Kluane National Park, roadside

spruce forest, Alaska Hwy. at squirrel research area, 60°57.226'N 138°02.466'W, *P. Caswell 03-037*, 12 June 2003 (DAO); dry organic soil, middle of road, abandoned road from Dalton Post to Wade Lakes, 60°06.192'N 137°07.847'W, *P. Caswell 24*, 6 June 2002 (DAO) (determined by G. A. Mulligan).

The first specimen cited above is from a site intermediate between two areas in the Park mapped by Cody (1996). The second specimen is the most southerly yet found in the Park about 30 kilometers south of a site reported in Cody et al. (2003).

Draba cinerea J. E. Adams, Gray-leaved Whitlow-grass – YUKON: Kluane National Park, moist organic soil on hill above an alpine marsh, nunatak at Logan Warden Cabin, 60°47.598'N 140°45.588'W, *P. Caswell et al. 03-328A*, 12 July 2003 (DAO) (determined by G. A. Mulligan).

The specimen cited above is the most southwesterly yet found in the Territory. It is from a site about 50 kilometers south of a site at about latitude 61°10'N (Cody 1996).

Draba crassifolia Grah., Rocky Mountain Whitlow-grass – YUKON: Kluane National Park, organic soil among large rocks, old lake bed, nunatak at Logan Warden Cabin, 60°47.500'N 140°44.991'W, *P. Caswell, R. Maraj & L. Fries 03-291*, 12 July 2003 (DAO) (determined by G. A. Mulligan).

The specimen cited above is an extension of the known range in the Park of about 80 kilometers west of two sites mapped by Cody (1996) and is the westernmost yet known in that area.

Draba lonchocarpa Rydb. var. *vestita* O. E. Schulz, Alaska Whitlow-grass – YUKON: Kluane National Park, rocks and gravel, Cache Lake, 61°12.454'N 139°03.757'W, *P. Caswell 60B*, 12 June 2002 (DAO) (determined by G. A. Mulligan); Kluane National Park, glacial till with thin organic cover, nunatak at Logan Warden Cabin, 60°47.628'N 140°45.148'W, *P. Caswell et al. 03-351*, 12 July 2003 (DAO) (determined by G. A. Mulligan).

Cody et al. (2001) reported the first record of this rare variety in the Territory from the extreme southeast. The specimens cited above extend the known range in the Territory about 1000 kilometers to the west to near the Alaska border.

Draba nivalis Liljebl., Snow Draba – YUKON: Kluane National Park, moist organic soil on hill above an alpine marsh, nunatak at Logan Warden Cabin, 60°47.598'N 140°45.588'W, *P. Caswell et al. 03-328A-B*, 12 July 2003 (DAO) (determined by G. A. Mulligan).

The specimen cited above is the most southwesterly yet found in the Territory. It is from a site about 100 kilometers west of a site at about 138°30'W (Cody 1996).

Draba oligosperma Hook., Few-seeded Draba, Few-seeded Whitlow-grass – YUKON: scree slope, dry rocky soil with little humus, abandoned road between Dalton Post and Wade Lakes, 60°05.992'N 137°08.531'W, *P. Caswell 02-25*, 6 June 2002 (DAO) (determined by G. A. Mulligan).

The specimen cited above which is the southernmost yet found in Kluane National Park is an extension of the known range in the Territory of about 75 kilometers southeast of a site southwest of Haines Junction.

Draba scotteri G. A. Mulligan – YUKON: Kluane National Park, scree with organic soil, alpine tundra, nunatak at Logan Warden Camp, 60°46.958'N 140° 44.864'W, *P. Caswell et al. 284*, 11 July 2003 (DAO); moist organic soil alpine tundra on hillside, nunatak at Logan Warden Cabin, 60°47.545'N 140°45.334'W, *P. Caswell et al. 03-176*, 10 July 2003 (DAO) (determined by G. A. Mulligan).

This is a rare species in the Territory (Douglas et al. 1981). The specimens cited above are from sites about 120 kilometers west of sites mapped by Cody (1996) in Kluane National Park.

Draba stenoloba Ledeb., Alaska Draba – YUKON: Kluane National Park, organic soil, right of way of abandoned pipeline, south of Auriol Trail, 60°42.932'N 137°25.565'W, *P. Caswell 03-70*, 21 June 2003 (DAO) (determined by G. A. Mulligan).

The specimen cited above is from a site intermediate between sites mapped by Cody (1996) on the Haines and Alaska highways.

Draba stenopetala Trautv., Starflowered Whitlow-grass – YUKON: small quantity of inorganic soil between two rocks, barren mountain summit, mountain east of Haines Hwy. just north of British Columbia border, 60°03.115'N 136°50.004'W, *L. Struever s.n.*, 1 July 2003 (DAO) (determined by G. A. Mulligan).

Douglas et al. (1981) knew this rare species in the Territory from only three sites in Kluane National Park. Cody (1996) mapped two additional sites east of the Dempster Hwy. and Cody et al. (2001) added two additional sites in the south at longitudes 135°29'W and 134°41'W. The specimen cited above is from a site about 30 kilometers east of the nearest site in southern Kluane National Park.

DROSERACEAE

Drosera anglica Huds., Great Sundew – YUKON: growing at edge of small thermokarst pond, Alaska Hwy. 6 km NW of Dry Creek #2, 62°13.455'N 140° 41.544'W, *B. A. Bennett, R. Elven & H. Solstad 03-046*, 8 Aug. 2003 (B. A. Bennett Herbarium, photo DAO).

This species was considered rare in the Territory by Douglas et al. (1981). The specimen cited above is from a site about 250 kilometers southwest of a site in the vicinity of Mayo (Cody 1996).

SAXIFRAGACEAE

Leptarrhena pyrolifolia (D.Don) R.Br. ex Ser., Leather-leaved Saxifrage – YUKON: Kluane National Park, Fisher Glacier near Alsek River, lower south-facing slope north of glacier, 60°08'31"N 138°13'13"W, *B. A. Bennett 03-978*, 6 July 2003 (Yukon Government Herbarium, photo DAO).

Cody (1996) knew this species in the Park from only two sites about halfway between this site and Haines Junction. The nearest other site was about 300 kilometers to the northeast adjacent to the South Canol Road.

Parnassia fimbriata Koenig, Fringed Grass-of-Parnassus – YUKON: Kluane National Park, Fisher Glacier near Alsek River, NE of base camp, common in open herbaceous and graminoid meadows of south-facing lower slopes north of camp, 60°08'31"N 138° 13'13"W, *B. A. Bennett 03-1066*, 8 July 2003 (DAO).

The specimen cited above is the southernmost yet found in the Park. It is about 50 kilometers southeast and southwest of the only two other sites mapped by Cody (1996) in the Park.

Saxifraga nelsoniana D.Don ssp. *carlottae* (Calder & Savile) Hultén (*S. punctata* L. ssp. *carlottae* Calder & Savile) – YUKON: in wet sand and gravel by streamlet on south side of large pond at Long Warden Cabin, nunatak, 60°47.628'N 140°45.148'W, *P. Caswell et al. 03-368*, 13 July 2003 (DAO).

The specimen cited above fits this subspecies which is new to the Yukon Territory (Cody 1996) on the basis of the scarcely cordate leaves with less than 12 lobes. It is, however, in flower and lacks the long, narrow, deeply cleft capsules. The following information is provided from Calder and Savile (1960): "Subspecies *carlottae* is abundant on moist alpine or subalpine slopes or clefts in the Queen Charlotte Islands; but it has also spread to the mainland where it intergrades freely with ssp. *pacifica* and ssp. *porsildiana*. ... Attention must be drawn to the plants in the Prince William Sound region of southern Alaska, cited as intermediate between ssp. *carlottae* and ssp. *pacifica*. These plants are actually closer in morphology to *carlottae* than *pacifica*, despite the occurrence of pure *pacifica* further east."

Saxifraga nelsoniana D.Don ssp. *pacifica* (Hultén) Hultén (*Saxifraga punctata* L. ssp. *pacifica* Hultén) – YUKON: Kluane National Park, Fisher Glacier near Alsek River, W-facing slope above valley glacier, 60°08'25"N 138°13'20"W, *B. A. Bennett 03-1001*, 7 July 2003 (DAO).

The specimen cited above is the most southwesterly yet found in the Park. It is from a site about 75 kilometers west of a site adjacent to the Haines Highway.

Saxifraga rufopilosa (Hultén) A. E. Porsild – YUKON: Kluane National Park, Fisher Glacier near Alsek River, W-facing slope above valley glacier, 60°08'20"N 138°13'20"W, *B. A. Bennett 03-996*, 7 July 2003 (DAO).

The specimen cited above is the southernmost yet found in the Park. It is from a site about 60 kilometers south of a site mapped by Cody (1996) southwest of Haines Junction.

ROSACEAE

Dryas integrifolia Vahl ssp. *crenulata* (Juz.) J. Kozhevn (*D. crenulata* Juz.) – YUKON: Kluane National Park, Fisher Glacier near Alsek River, base camp, common on south and west-facing slopes and occasionally on upper slopes and in valley, 60°08'31"N 138°13'13"W, *B. A. Bennett 03-978*, 6 July 2003 (B. A. Bennett Herbarium, photo DAO).

The specimen cited above is the southernmost yet found in the Park. It is from a site about 100 kilometers south of a site mapped by Cody (1996) southeast of Kluane Lake.

Dryas octopetala L. ssp. *hookeriana* (Juz.) Hultén (*D. hookeriana* Juz.) – YUKON: Kluane National Park, Fisher Glacier near Alsek base camp, common on south- and west-facing slopes, 60°08'31"N 138°13'13"W, *B. A. Bennett 03-1085*, 6 July 2003 (B. A. Bennett Herbarium, photo DAO).

The specimen cited above is the southernmost yet known in the Park. It is about 30 kilometers south of a site southwest of Haines Junction mapped by Cody (1996).

Luetkea pectinata (Pursh) Kuntze, Partridge-foot – YUKON: Kluane National Park, Fisher Glacier near Alsek River, west-facing slope above valley glacier leading into Fisher Glacier, 60°08'16"N 138°13'28"W, *B. A. Bennett 03-988*, 7 July 2003 (Yukon Government Herbarium, photo DAO).

This species was known to Cody (1996) from only two sites in the southeast of the Park. The specimen cited above is an extension of the known range in the Park of about 25 kilometers west of the southernmost site.

Potentilla bipinnatifida Dougl. ex Hook., Bipinnate Cinquefoil – YUKON: Kluane National Park, packed earth and gravel with organic component, centre of road, Alsek Trail, *P. Caswell 02-437*, 12 July 2002 (DAO).

Cody (1996) stated that this species was apparently rare in northern and southwestern parts of the Territory but it was not included in *The Rare Vascular Plants of the Yukon Territory* (Douglas et al. 1981). The specimen cited above is from a site intermittent between two sites mapped by Cody in the Park.

Rosa woodsii Lindl., Western Rose – YUKON: Pelly Crossing, growing on upper south-facing 45°bluff slope, 62°49'57"N 136°34'45"W, *B. A. Bennett 03-095*, 1 Sept. 2003 (DAO).

The specimen cited above is an extension of about 90 kilometers north of Carmacks.

Sorbus sitchensis Roemer – YUKON: Kluane National Park, Fisher Glacier near Alsek River, NE of base camp, only a single plant seen in open herbaceous and graminoid meadows of south-facing lower mid-slope growing 1.5 meters tall, 60°08'31"N 138°13'13"W, *B. A. Bennett 03-1071*, 8 July 2003 (DAO).

This species which was considered rare in the Territory by Douglas et al. (1981) was known to Cody (1996) from only two nearby sites in the extreme south of Kluane National Park. The specimen cited above is an extension of the known range in the Territory of about 25 kilometers to the west.

LEGUMINOSAE (FABACEAE)

Astragalus alpinus L., Alpine Milk-vetch – YUKON: Kluane National Park, nunatak between Lowell and Dusty glaciers, near Ulu Mountain, 60°21'32"N 138° 34'49"W, *B. A. Bennett 03-941*, 6 July 2003 (DAO).

The specimen cited above is from the most southwesterly site in the Park. This site is about 25 kilometers west of a site mapped by Cody (1996).

Lupinus nootkatensis Donn ex Sims, Nootka Lupine – YUKON: Kluane National Park, Fisher Glacier near Alsek River, slope above valley glacier leading into the glacier, 60°08'16"N 138°28'W, *B. A. Bennett 03-1006*, 7 July 2003 (Yukon Government Herbarium, photo DAO).

The specimen cited above is an extension of the known range in the Park of about 25 kilometers southwest of this rare species in the Territory (Douglas et al. 1981) which was known to Cody (1996) from only two sites in the extreme south and an additional site adjacent to the Haines Highway (Cody et al. 2004).

Oxytropis arctica R.Br. var. *arctica*, Arctic Oxytrope – YUKON: Vuntut National Park, ca. 13 miles W of Sam Lake, 68.35°N 139.1667°W, *S. L. Welsh 10340*, 9 July 1970 (ALA).

Cody (1996) described and keyed this species, which is known from arctic Canada and northern Alaska, and suggested that it should be looked for in the mountains of northern Yukon Territory. It should be added to the list of rare plants in the Territory (Douglas et al. 1981).

Oxytropis arctica R.Br. var. *murrayi* (Yurtzev) S. Welsh (*O. sordida* [Willd.] Pers. ssp. *murrayi* B. A. Yurtsev), Murray's Oxytrope – YUKON: Kluane National Park, Observation Mtn. and vicinity at terminus of Kaskawulsh Glacier, 60.8167°N 138.7334°W, *D. F. and B. Murray 522*, 10 July 1966 (ALA); Kluane National Park, Fisher Glacier near Alsek River, west-facing 15° slope, above valley glacier in *Dryas integrifolia* heath tundra with *Hedysarum boreale*, *Senecio ogortorukensis*, some limestone in the thin soil, just nearing ridge, 60°08'12"N 138°13'14"W, *B. A. Bennett 03-981*, 7 July 2003 (DAO).

This plant was fairly common on this site but became less common quickly as you follow the ridge to the summit. This is a new variety first reported in Cody et al. (2004) in flora of the Yukon Territory, which is endemic to Kluane National Park. It should be added to the list of rare plants (Douglas et al. 1981). *Oxytropis arctica* var. *murrayi* can be separated from var. *arctica* as follows:

A. Leaves seldom with some leaflets fasciculate; leaflets often over 8 mm long, at least some, plants of arctic in N Yukon ..... var. *arctica*

A. Leaves typically with fasciculate leaflets; leaflets mainly less than 8 mm long; plants of SW Yukon ..... var. *murrayi*

Oxytropis arctica var. *murrayi* can be described as follows: Plants mainly 4-16 cm tall. Leaves 3-12 cm long; leaflets 17-numerous, opposite, scattered or more typically fasciculate, mainly 3-8 mm long, but in some up to 14 mm. Scapes 4-12 (14) cm; racemes 2-7 flowered, subcapitate or slightly elongate; calyx tube shaggy villous with light and dark hairs, 4-5 mm long. Pods 17-21 mm, spreading. Type: Yukon, St. Elias Mts., Observation Mt. and vicinity, at terminus of Kaskawulsh Glacier, *D. F. & B. M. Murray 522*, 10 July 1966. Flowering in summer. Ridge crests, talus slopes, and meadows at 725-1830 m.

Oxytropis campestris (L.) DC. ssp. *jordalii* (A. E. Porsild) Hultén, Jordal's Oxytrope – YUKON: Kluane National Park, Fisher Glacier near Alsek River, NE of base camp, drier open south-facing mid slope, 60°08'31"N 138°13'13"W, *B. A. Bennett 03-1070*, 8 July 2003 (DAO); west-facing slope 40°-50°, above valley glacier leading into Fisher Glacier, 60°08'16"N 138°13'28"W, *B. A. Bennett 03-992*, 7 July 2003 (B. A. Bennett Herbarium, photo DAO).

The specimens cited above are the first reported from Kluane National Park and are an extension of the known range in the Territory of about 200 kilometers west of sites in the vicinity of Carcross (Cody 1996).

Oxytropis nigrescens (Pall.) Fisch. ssp. *nigrescens*, Blackish Locoweed – YUKON: Kluane National Park, Fisher Glacier near Alsek River, west-facing slope 40°-50° above valley glacier leading into Fisher Glacier, 60°08'16"N 138°13'28"W, *B. A. Bennett 03-991*, 7 July 2003 (DAO).

The specimen cited above is an extension of the known range in the Park of about 75 kilometers south of a site mapped by Cody (1996) west of Haines Junction.

Vicia americana Muhl., American Vetch – YUKON: behind cabins, north end of Dawson City by Whitehorse Cabins, 64°04'N 139°26'W, *G. Brunner 585*, 12 Sept. 2003 (DAO).

The collection cited above is from a site about 175 kilometers west-northwest of Mayo and was undoubtedly introduced there.

GERANIACEAE

Geranium erianthum DC., Northern Geranium – YUKON: Kluane National Park, organic soil in meadow, Plug Creek, 60°03.593'N 138°12.055'W, *P. Caswell et al. 03-675*, 29 July 2003 (DAO).

This is a rare species in the Territory (Douglas et al. 1981) where it is mainly found in Kluane National Park. The specimen cited above is the westernmost site adjacent to the British Columbia border.

VIOLACEAE

Viola adunca J. E. Smith, Hook-spur Violet – YUKON: Kluane National Park, growing in shady areas under willows by small creek on west slope above valley glacier leading into Fisher Glacier near Alsek River, 60°08'10"N 138°13'15"W, *B. A. Bennett 03-985*, 7 July 2003 (DAO).

The specimen cited above is an extension of the known range in the Park of about 35 kilometers northwest of a site mapped by Cody (1996) near the British Columbia border.

ONAGRACEAE

Epilobium hornemannii Reichenb. ssp. *hornemannii*, Hornemann's Willowherb – YUKON: Kluane National Park, dry wind-packed fine scree, nunatak north of Lowell Glacier, 60°18.297'N 138°34.503'W, *P. Caswell 03-604*, 29 July 2003 (DAO).

The specimen cited above is an extension of the known range into southern Kluane National Park of about 100 kilometers southwest of a site east of Haines Junction (Cody 1996).

HALORAGACEAE

Myriophyllum verticillatum L., Verticillate Water-milfoil – YUKON: muddy substrate, in two feet of water,

growing in dense clumps, Poison Lake, 60°14.686'N 136°57.421'W, *P. Caswell 03-493*, 24 July 2003 (DAO).

This is a rare species in the Territory (Douglas et al. 1981). The specimen cited above is an extension of the known range of about 80 kilometers southeast of a site northwest of Haines Junction (Cody 1996).

APIACEAE

Angelica lucida L., Seacoast Angelica – YUKON: Kluane National Park, moist, organic soil, Plug Creek, 60°03.593'N 138°12.055'W, *P. Caswell et al. 03-666*, 29 July 2003 (DAO).

This is a rare species in the Yukon Territory (Douglas et al. 1981). The specimen cited above is the westernmost yet known in the Territory and is an extension of about 75 kilometers west of the Lower Alsek River in the extreme southeast of the Park (Douglas and Ruyle-Douglas 1978).

ERICACEAE

Harrimanella stellariana (Pallas) Coville (*Cassiope stellariana* (Pallas) DC.), Alaskan Mountain-heather – YUKON: Kluane National Park, abundant sometimes forming nearly pure stands covering areas in the lower valley and the lower north-facing slopes, Fisher Glacier near Alsek River, base camp, 60°08'31"N 138° 13'13"W, *B. A. Bennett 03-953*, 6 July 2003 (DAO).

This species was reported as rare in the Territory by Douglas et al. (1981) on the basis of only three known sites, two of which were in Kluane National Park. The specimen cited above is an extension of about 25 kilometers to the west in the Park.

Phyllodoce × *intermedia* (Hook.) Rydb. – YUKON: Kluane National Park, Fisher Glacier near Alsek River, southwest-facing slope 30° above Fisher Glacier, 60°08'06"N 138°12'58"W, *B. A. Bennett 03-1035*, 7 July 2003 (B. A. Bennett Herbarium, photo DAO).

Cody et al. (2001) reported the first known occurrence of this hybrid between *Phyllodoce empetriformis* and *P. glandulifera* from a wooded site near Kathleen Lake at about Mile 140 Haines Road, about 75 kilometers northwest of the second site in Kluane National Park.

PRIMULACEAE

Douglasia ochotensis (Willd.) Hultén, Arctic-Montane Dwarf-Primrose – YUKON: Dempster Highway kilometer 440, 4 km southwest of Rock River Campground with *Salix phlebophylla* in platey loose shale slope, 66°52'37"N 136°19'58"W, *B. A. Bennett 03-078*, 13 Aug. 2003 (DAO).

The specimen cited above is the easternmost yet found in the Territory. It is from a site about 175 kilometers southeast of the nearest site mapped by Cody (1996).

Primula nutans Georgi (*P. sibirica* Jacq.), Siberian Primrose – YUKON: damp organic soil, uneven tundra, Alaska Hwy. at squirrel research area, 60°57.156'N 138°02.086'W, *P. Caswell 03-034*, 12 June 2003 (DAO).

This Amphi-Beringian species is found in North America in extreme western Alaska and then disjunct to eastern Alaska and southwestern Yukon Territory (Hultén 1968). The specimen cited above is a slight extension to the northwest from sites in the Haines Junction region mapped by Cody (1996).

GENTIANACEAE

Swertia perennis L., Alpine Bog Swertia – YUKON: wet organic soil, open *Picea glauca* forest, second gully east of Haines Highway proceeding north from the British Columbia border, 60°00.403'N 136°51.061'W, *P. Caswell 03-546*, 2 Aug. 2003 (DAO).

Cody (1996) suggested that this species was to be looked for in southwestern Yukon Territory. It has now been found and should be added to the list of rare plants in the Territory.

MENYANTHACEAE

Menyanthes trifoliata L., Buckbean, Bogbean – YUKON: pond west of Alaska Hwy., north of Donjek bridge, 61°41'11.8"N 139°47'01.6"W, *D. Normadeau s.n.*, 26 July 2003 (DAO); emergent in highway pond, 4 km SE of Pickhandle Lake, 61°54'20"N 140°13'00"W, *B. A. Bennett 97-27*, 6 June 1996 (DAO); "Eagle Lake", 61°23'30"N 139°41'30"W, *R. D. Wickstrom s.n.*, 20 Aug. 1974 (DAO).

The three sites cited above extend the known range in the Territory about 115 kilometers southeast of a site adjacent to the Alaska Hwy. and Alaska border.

APOCYNACEAE

Apocynum androsaemifolium L., Spreading Dogbane – YUKON: in open dry *Pinus contorta*/lichen woods, Watson Lake area, 60°11'N 129°05'W, *R. Rosie 1893*, 6 July 1995 (DAO); open Pine/Lichen bluff above lake, Blind Lake, 60°04'43.3"N 128°15'3.7"W, *J. Staniforth 2*, 26-28 June 2003 (DAO).

Cody (1996) knew this species as occasional north to the vicinity of Dawson City. The specimens cited above are from sites west of the easternmost mapped by Cody.

POLEMONIACEAE

Polemonium pulcherrimum Hook., Showy Jacob's Ladder – YUKON: Kluane National Park, nunatak between Lowell and Dusty glaciers near Ulu Mountain, on 35-40° south-facing slope, 60°21'32"N 138° 34'49"W, *B. A. Bennett 03-923*, 6 July 2003 (DAO).

The specimen cited above is from a site intermediate between two sites in the extreme south of the Park about 125 kilometers apart.

VERBENACEAE

Verbena hastata L. – A specimen which was collected by Phil Caswell at Haines Junction on 13 August 2000 was identified to this species by B. A. Bennett and confirmed by W. J. Cody. It was reported as new to the Yukon Territory by Cody et al. (2003). Unfortunately this specimen was misidentified and has been correctly revised to *Veronica longifolia* L., by Stuart G. Hay of the Herbier Marie-Victorin (MT), Université de Montréal, a species which was first collected along the Alaska Hwy. by Cody and Ginns in July 1980. *Verbena hastata* should be deleted from the flora of the Yukon Territory.

SCROPHULARIACEAE

Castilleja miniata Dougl. ex Hook., Scarlet Paintbrush – YUKON: Kluane National Park, moist, organic soil, meadow on north shore of first lake from St. Elias Lake, Secret Lakes, 60°18.979'N 137°08.208'W, *P. Caswell & L. Freese 03-524*, 26 July 2003 (DAO).

This species was considered rare in the Territory by Douglas et al. (1981) who knew it only east of Atlin Lake and the Larson Creek hot springs. Catherine Kennedy collected it at the Coal River Springs area in 1983 (Cody 1994) and Mark Egger collected it adjacent to the Top of the World Hwy. west of Dawson City in 1991 (Egger 1992). The specimen cited above is a new record for Kluane National Park, about 200 kilometers west of the site near Atlin Lake.

Castilleja parviflora Bong., Small-flowered Paintbrush – YUKON: Kluane National Park, scree with a small organic component, nunatak (abandoned weather station) north of Lowell Glacier, 60°18.297'N 138°34.503'W, *P. Caswell et al. 03-603*, 29 July 2003 (DAO).

This rare plant in the Territory (Douglas et al. 1981) is only known in the Territory in the southeast of Kluane National Park. The specimen cited above is from a site about 75 kilometers northwest by west of the southernmost mapped by Cody (1996).

Castilleja unalaschcensis (Willd.) Hultén, Unalaska Paintbrush – YUKON: Kluane National Park, Fisher Glacier near Alsek River, southwest-facing 30° slope above Fisher Glacier, 60°08'06"N 138°12'58"W, *B. A. Bennett 03-1021*, 7 July 2003 (DAO).

The specimen cited above is an extension of the known range in the southern part of the Park of about 30 kilometers west of a site mapped by Cody (1996).

Veronica americana Schwein., American Brooklime – YUKON: Haines Hwy., interface of dried mud and water, beaver pond on east side of highway about 10 km south of Kathleen Lake cutoff, 60°30.838'N 137° 04.970'W, *P. Caswell 02-788*, 11 Aug. 2002 (DAO).

Cody (1996) reported this species as occasional in the Territory north to about latitude 63°N. The specimen cited above is from a site about 80 kilometers southeast of the westernmost location in the Territory adjacent to the Alaska Hwy.

OROBANCHACEAE

Orobanche fasciculata Nutt., Clustered Broomrape – YUKON: mid-slope, Conglomerate Mountain, 61.6252°N 135.8755°W, *B. A. Bennett & S. Thompson 03-011*, 2 May 2003 (DAO); old esker complex with silty soil, gravel and boulders at crest of south-facing slope, Haunka Creek, 60°14'05.4"N 133°53'29.3"W, *B. A. Bennett, R. & P. Mulder 04-0052*, 22 May 2004 (DAO).

Douglas et al. (1981) considered this species rare in the Territory. The first specimen cited above is from a site intermediate between Carmacks and a site just north of Whitehorse (Cody 1996). The second specimen cited above is an extension of about 30 kilometers to the southeast of a site mapped by Cody (1996) adjacent to the Alaska Hwy. and is the southernmost yet known in the Territory.

LENTIBULARIACEAE

Utricularia minor L., Lesser Bladderwort – YUKON: Kluane National Park, in five inches water, muddy substrate, pond at Slims East Trailhead, 60°59.408'N 138°29.483'W, *P. Caswell 03-541*, 28 July 2003 (DAO).

The specimen cited above is an extension of the known range of this uncommon species in the Territory of about 300 kilometers west of a site near the south end of the Canol Road (Cody 1996). It is new to Kluane National Park.

PLANTAGINACEAE

Plantago eriopoda Torr., Saline Plantain – YUKON: dry gravel, edge of parking space, Burwash Landing Airport, 61°22.183'N 139°01.842'W, *P. Caswell 02-319*, 6 July 2002 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 75 kilometers northwest of a site adjacent to the Alaska Hwy. northwest of Haines Junction (Cody 1996).

RUBIACEAE

Galium triflorum Michx., Sweet-scented Bedstraw – YUKON: organic soil at edge of thicket on west-facing slope, east of Haines Hwy. at Km 152, 60°02.970'N 136°53.001'W, *P. Caswell 03-746*, 21 Aug. 2003 (DAO).

This is a rare species in the Territory (Douglas et al. 1981). The specimen cited above is an extension of the known range of about 140 kilometers southeast of a site near the south end of Kluane Lake.

CAPRIFOLIACEAE

Lonicera involucrata (Richards.) Banks ex Spreng., Black Twinberry – YUKON: Haines Junction, *L. Fournier s.n.*, July 1958 (DAO).

The specimen cited above was likely collected from cultivated plants. In the Yukon, it is known only from persisting plantings.

VALERIANACEAE

Valeriana sitchensis Bong., Sitka Valerian – YUKON: Kluane National Park, moist organic soil, Plug Creek, 60°03.593'N 138°12.055'W, *P. Caswell 03-647*, 29 July 2003 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 25 kilometers to the southwest of a site mapped by Cody (1996).

CAMPANULACEAE

Campanula rotundifolia L., Harebell – YUKON: Kluane National Park, open soil with *Festuca altaica*, *Arcostaphylos uva-ursi*, *Juniperus communis*, *Shepherdia canadensis*, *Populus balsamifera*, and *Potentilla fruticosa*, Fisher Glacier near Alsek River, 60°07'54"N 138°12'23"W, *B. A. Bennett 03-1052*, 8 July 2003 (B. A. Bennett Herbarium, photo DAO).

This species was considered rare in the Territory by Douglas et al. (1981). The specimen cited above is from the third site in Kluane National Park and is an extension of about 30 kilometers west of a site mapped by Cody (1996).

ASTERACEAE

Antennaria pulcherrima (Hook.) Greene, Showy Pussytoes – YUKON: Watson River, near mouth by Carcross Dunes, 60°11'05"N 134°44'16"W, *B. A. Bennett & R. Mulder 03-1308*, 17 Aug. 2003 (DAO).

The specimen cited above is an extension of the known range in the Territory (Cody 1996) of about 125 kilometers west of a site in the vicinity of Teslin.

Arnica diversifolia Greene, Diverse Arnica – YUKON: Kluane National Park, scree with organic component, mountain slope, old weather station on nunatak north

of Lowell Glacier, 60°18.297'N 138°34.503'W, *P. Caswell et al. 03-597*, 29 July 2003 (DAO).

This is a rare species in the Territory (Douglas et al. 1981) where it was known from a site near the south end of Kluane Lake in Kluane National Park. The specimen cited above is a southward extension of the known range in the Park of about 75 kilometers.

Arnica latifolia Bong., Mountain Arnica – YUKON: Kluane National Park, Fisher Glacier near Alsek River, 45° southwest-facing slope above Fisher Glacier, silty sandy soil, 60°08'03"N 138°12'54"W, *B. A. Bennett 03-1033*, 7 July 2003 (DAO).

The specimen cited above is the fourth yet known in the Park and the most westerly yet known in the Territory (Cody 1996).

Artemisia tilesii Ledeb. s.l., Aleutian Mugwort – YUKON: Kluane National Park, occasional on xeric rock outcrops in shallow soil on edge of extremely steep cliffs, also seen at base of mountain, Fisher Glacier near Alsek River, 60°08'06"N 138°12'42"W, *B. A. Bennett 03-1022*, 7 July 2003 (DAO).

The specimen cited above is an extension of the known range in the Park of about 30 kilometers to the west from a site in the extreme south. This specimen is a very distinct form with rounded leaflets and dark bracts and may represent a new variety.

Cirsium foliosum (Hook.) DC., Leafy Thistle, Elk Thistle – YUKON: Beaver Pond on McIntyre Creek across from Kopper King, Whitehorse, 60°44.73'N 135°07.36'W, *G. Delaet, B. A. Bennett & R. Mulder 03-1370*, 29 Sept. 2003, (B. A. Bennett Herbarium, photo DAO).

The specimen cited above is from a site intermediate between sites adjacent to the South Canol Road and Haines Hwy. mapped by Cody (1996).

Erigeron grandiflorus Hook. ssp. *arcticus* A. E. Porsild, Large-flowered Daisy – YUKON: Kluane National Park, organic soil on south-facing slope of alpine meadow, Wade Mountain, 61°18.373'N 139°31.273'W, *P. Caswell 02-374*, 7 July 2002 (DAO).

This species was not included in *The Rare Plants of the Yukon* (Douglas et al. 1981) because of its widespread range. The specimen cited above is a short distance northwest of the westernmost site mapped by Cody (1996) in the Kluane National Park.

Erigeron humilis Graham, Arctic-alpine Daisy – YUKON: Kluane National Park, south-facing alpine slope, nunatak (abandoned weather station) north of Lowell Glacier, 60°18.297'N 138°34.503'W, *P. Caswell 03-591*, 29 July 2003 (DAO).

The specimen cited above is the most southwesterly yet known in Kluane National Park (Cody 1996). The nearest known site is about 25 kilometers to the northeast.

Erigeron peregrinus (Banks ex Pursh) Greene ssp. *peregrinus*, Subalpine Daisy – YUKON: Kluane National Park, moist organic soil, meadow, Plug Creek, 60° 03.593'N 138°12.055'W, *P. Caswell et al. 03-651*, 29 July 2003 (DAO).

This subspecies was considered rare in the Territory by Douglas et al. (1981). The specimen cited above is an extension of the known range in the Territory of about 30 kilometers west of a site near the British Columbia border.

Erigeron pumilus Nutt., Shaggy Fleabane – YUKON: Kluane National Park, Donjek Valley, 61°00'N 139° 22.573'W, *R. Maraj s.n.*, 15 July 2002 (DAO).

Douglas et al. (1981) reported this species as rare in the Yukon Territory on the basis of a specimen collected in the vicinity of Kluane Lake. The specimen cited above is only the second known in the Territory. It was collected about 65 kilometers to the southwest and is a new record for Kluane National Park.

Erigeron uniflorus L. ssp. *eriocephalus* (Vahl ex Hornem.) Cronq., Northern Daisy – YUKON: Kluane National Park, alpine scree slope, nunatak at Logan Warden Cabin, 60°46.889'N 140°45.108'W, *P. Caswell et al. 03-264*, 11 July 2003 (DAO).

Douglas et al. (1981) considered this species rare in the Territory. The specimen cited above which is about 50 kilometers southwest of the westernmost mapped by Cody (1996) in Kluane National Park is now the westernmost yet known in the Park.

Erigeron yukonensis Rydb., Yukon Fleabane – YUKON: organic soil, flat burned area of dead *Picea glauca*, Copper Joe Creek, 61°18.641'N 138°56.324'W, *P. Caswell 02-156*, 24 June 2002 (DAO); barren ridge, 50% vegetative coverage, east-facing slope 2°, inorganic soil with *Dryas intergrifolia* ssp. *intergrifolia* and *Saxifraga tricuspidata*, Thunder Egg Mountain, collected by Z. Mattson 60°47.777'N 137°46.993'W, *P. Caswell 04-058* (Kluane Park Herbarium, photo DAO).

This species is an endemic of the Yukon Territory and adjacent District of Mackenzie (Cody 1996). The first specimen cited above is an extension of the known range in the Territory of about 100 kilometers northwest of a site in Kluane National Park southwest of Haines Junction.

Hieracium gracile Hook., Slender Hawkweed – YUKON: Kluane National Park, Fisher Glacier near Alsek River, west-facing slope above valley glacier leading into Fisher Glacier, 60°08'16"N 138°13'28"W, *B. A. Bennett 03-987*, 7 July 2003 (DAO).

The specimen cited above is an extension of the known range about 35 kilometers west of the southernmost previously known to Cody (1996) in the Park.

Symphyotrichum ciliatum (Lindl.) A. & D. Löve (*Aster brachyactis* Blake) Rayless Aster, Lindley's American Aster – YUKON: growing in silty saline mud along east shore and amongst *Puccinellia*, *Triglochin palustris*, *Triglochin maritima* and *Lomatagonium rotatum*, Fox Creek saline flat 600 m south of Fox Creek, Km 227 on east side of North Klondike Hwy., *B. A. Bennett & R. Mulder 03-1341*, 13 Sept. 2003 (DAO).

Douglas et al. (1981) considered this species rare in the Territory on the basis of a single site at an alkaline meadow adjacent to the Takhini River west of Whitehorse. The specimen cited above from north of Whitehorse is from only the second known site in the Territory.

Symphyotrichum yukonense (Cronquist) Nelson (*Aster yukonensis* Cronquist), Yukon Aster, Yukon-American Aster – YUKON: silty broad alkaline river flat, northwest side of Donjek River, 61°40.8'N 139°45.58'W,

B. A. Bennett, R. Elven & H. Solstad 03-053, 8 Aug. 2003 (DAO).

This species was considered rare in the Territory by Douglas et al. (1981). The specimen cited above is an extension of the known range in the Territory of about 100 kilometers northwest of sites in the vicinity of the south end of Kluane Lake.

Taraxacum lyratum (Ledeb.) DC., Rock Dandelion – YUKON: Kluane National Park, Fisher Glacier near Alsek base camp, occasional in valley bottom in heath tundra, 60°08'31"N 138°13'13"W, *B. A. Bennett 03-956*, 6 July 2003 (DAO).

The specimen cited above is from the southernmost site yet found in the Park. It is from a site about 30 kilometers south of the southernmost previously known to Cody (1996).

Acknowledgments

We thank Gerald A. Mulligan for the identification of Brassicaceae (Cruciferae) specimens; George Argus for the identification of *Salix niphoclada*; Stephen Darbyshire for identification of *Agrostis humilis, Festuca brachyphylla*, *Bromus japonicus,* and *Rumex maritimus* ssp. *fheginus;* M. Barkworth for identification of *Psathyrostachys juncea;* Paul Catling for identification of *Carex lasincarpa;* Julie A. Dragon for identification of *Carex lenticularis* var. *dolia;* R. Elven and H. Solstad for the identification of *Papaver radicatum* ssp. *kluanensis*, R. Elven for the identification of *Stellaria umbellata;* A. A. Reznicek for identification of several species of *Carex*; M. Costea for identification of *Polygonum achoreum*; Paul Catling for reviewing an earlier version of this manuscript and Leslie Cody for the many hours inputting this information on her computer.

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Received 5 May 2005
Accepted 23 July 2005

Additions to the Flora of the Continental Northwest Territories from the Great Slave Lake Area

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Catling, Paul M. 2005. Additions to the flora of the continental Northwest Territories from the Great Slave Lake area. Canadian Field-Naturalist 119(3): 437-440.

Eleven species are reported as new to the flora of the continental Northwest Territories. The new native species include *Artemesia dracunculus*, *Chenopodium leptophyllum*, *Eleocharis erythropoda*, *Panicum capillare*, *Schoenoplectus pungens* and *Symphyotrichum lanceolatum* subsp. *hesperium* var. *hesperium*. New alien species reported include *Achillea ptarmica*, *Chaenorhinum minus*, *Galium aparine*, *Malva neglecta* and *Silene cserei*. *Sonchus arvensis*, previously reported, is based on material referable to a subsp. *uliginosus*. Forms new to the flora include *Achillea millefolium* f. *rosea* and *Actaea rubra* f. *neglecta*. Locations, habitats and distinctive features are provided for the additional taxa. The Hay River lowland ecoregion is a floristically rich area that deserves more botanical exploration.

Key Words: Additions, range extensions, vascular plants, Northwest Territories, Canada.

The flora of the Northwest Territories (NWT) has been extensively studied by many botanists as outlined by Porsild and Cody (1980) with more recent work indicated by Catling et al. (2005*). Four days of studying the flora in southern NWT yielded 11 species not previously recorded. This suggests that either the flora is changing or that parts of the area are understudied, or both. These possibilities are briefly discussed and the additional species are included in an annotated list presented below.

The latitude, longitude, and collection dates for all locations mentioned in the text are indicated in Table 1 and the coordinates are correct to 200 m. In all cases the collector is P. M. Catling. Specimens documenting occurrences are preserved in the Agriculture and Agri-Food Canada collection (DAO, see Holmgren et al. 1990 for an explanation of herbarium acronyms) in Ottawa.

Phytogeographic aspects

Native species

All but one (*Chenopodium leptophyllum*) of the additional native species are southern plants now reaching their northern limits at Hay River. This region south and west of Great Slave Lake is already known to be a distinctive phytogeographic zone where many southern species reach their northern limits and is also an area where many arctic and alpine plants are absent but otherwise occur throughout NWT (e.g., Raup 1947, page 66 lower figure). The area has been designated as the Hay River lowland ecoregion (number 64) of the Taiga Plain ecozone (Ecological Stratification Working Group 1995). It was designated as the Southern Boreal Province by McJannet et al. (1995).

The climate warming trend in northern Canada will make it possible for plants to extend their distributions

TABLE 1. Locations, habitats, collection dates and latitude and longitude of places in Northwest Territories where additions to the flora were discovered by P. M. Catling in 2003.

Habitat and Location	Date	Latitude	Longitude
periodically flooded shore of Hay River at Hay River	30 July 2003	60.4900	115.7304
open vacant land and shoreline at port of Hay River	30 July 2003	60.8214	115.7304
bank of Hay River near West Channel bridge N side of Hay River	30 July 2003	60.8536	115.7743
bulldozed area beside Niven Lake, N side of Yellowknife	30 July 2003	62.4603	114.3745
vacant lots in Yellowknife	30 July 2003	62.4500	114.4300
open sand prairie, Taltson River W of Fort Smith	23 July 2003	60.3554	111.2760
open rocky ridge, Ingraham Trail, E of Yellowknife	28 July 2003	62.5037	114.2764

northward but warming is not likely to be an explanation for new records of native species reported here. Warming to the extent of promoting northward range extension may not have occurred yet and the new native species are easily overlooked in cursory botanical inventory. Consequently they are likely to be long-established in the area. Unlike the Fort Simpson, Fort Smith and Wood Buffalo areas in the Hay River lowland, the region of Hay River itself has not been sufficiently studied from a botanical viewpoint. There are only few and small collections from the area including those of W. H. Lewis in 1951 (at DAO) reported by Cody (1956) and collections made in 1971 by L. Dahike (at CAN and WAT) and by P. Ducruc, both included in Porsild and Cody (1980). An examination of the maps in Porsild and Cody (1980) indicates that many plants likely to occur in the area have not been recorded.

Introduced species

There are few published studies of the flora of man-made disturbed habitats such as the Norman Wells pipeline study (Cody et al. 2000). In an unpublished report involving the non-cultivated urban flora of Yellowknife, Steinecke (2001*) gathered information on 135 sites within the city limits. The sampled habitats included roadsides, lawns and vacant lots. A total of 142 species were recorded in the town, 55% of which were alien. Of these, 25 are additions to the flora (Porsild and Cody 1980; Catling et al. 2005*), including *Acer negundo* L., *Aconitum* sp., *Alopecurus occidentalis* Scribn. & Tweedy (probably *A. arundinaceus* Sobol which is not new), *Amsinckia menziesii* (Lehm.) Nels. & Macbr., *Artemesia absinthium* L., *Campanula rapunculoides* L., *Dianthus barbatus* L., *Halenia deflexa* (Smith) Giseb., *Hordeum vulgare* L., *Malva rotundifolia* L., *Panicum miliaceum* L. (introduced with bird seed around feeders but possibly not persisting), *Portulaca oleracea* L., *Ranunculus repens* L., *Rheum rhabarbarum* L., *Rumex crispus* L., *Setaria glauca* (L.) Beauv., *Sonchus uliginosus* Bieb., *Spiraea* cf. *betulifolia* Pallas and *Tropaeolum* sp. Since this interesting study is unpublished and there are no specimen vouchers, the records are not accepted as additions, but they are nevertheless of interest and, hopefully, they will be supported by vouchers in the future.

As settlement expands and road traffic increases it is likely that more introduced species will expand into the region by gradual spread along corridors of disturbed habitats such as roads, but also through long distance dispersal by people incidentally transporting soil and seeds on or in vehicles. That such spread of alien species is continuing is suggested by the additional species reported by Steinecke (200*, listed above) and the five additional alien species reported here. The latter originated from open disturbed sites in either the town of Yellowknife or the town of Hay River. More alien species are expected to enter the region and some may begin to impact native flora and fauna, but with the possible exception of *Phalaris canariensis* L. (recently reported to be a local problem), there is little evidence of spread into native plant communities.

Annotated List of Additional Species

Achillea millefolium L. f. *rosea* Rand. & Redf.
YARROW (rose-flowered form)

Although the species is well known from NWT, this unusual form with deep rose-purple (instead of white) ligules has not been recorded previously. Found in a bulldozed area beside Niven Lake on N side of Yellowknife, it is occasionally cultivated and likely a garden escape.

Achillea ptarmica L.
PEARL YARROW

Found in an open bulldozed area beside Niven Lake on N side of Yellowknife, this introduced species differs from *A. sibirica* Ledeb. in its serrated instead of pectinate leaves and longer ligules to 5 mm. This species is sometimes introduced with "wildflower" seed mixtures.

Actaea rubra (Ait.) Willd. f. *neglecta* (Gillman) Robins.
RED BANEBERRY (white berry form)

This white-fruited form of this native plant is abundant in some parts of the extensive North American range, but previously only "bright red or rarely pink" fruits have been reported for NWT (Porsild and Cody 1980). Several plants were found on a wooded bank of the Hay River near bridge on north side of town.

Artemesia dracunculus L.
DRAGON WORMWOOD

This native, linear-leaved species of dry hills and prairies was expected to be discovered in NWT by Porsild and Cody (1980). It was found in open sandy ground on banks of the Hay River at Hay River.

Chaenorhinum minus (L.) Lange
DWARF SNAP-DRAGON

This distinctive, glandular-hairy, introduced plant was frequent in open gravelly areas and along the railway at the port of Hay River. The 5-7 mm flowers are bluish-purple with yellow in the throat.

Chenopodium leptophyllum (Moquin-Tandon) Nuttall ex S. Watson
NARROW-LEAF GOOSEFOOT

Porsild and Cody (1980) listed this species but excluded it based on the Richardson specimen collected at Fort Franklin on Great Bear Lake "where it was surely an ephemeral introduction." Clements and Mosyakin (2003) show its occurrence in Alberta near the NWT border but not in NWT. It was found on a disturbed sandy portion of an open prairie slope adjacent to the Taltson River east of Fort Smith. At this location it occurred around an open sandy blowout on dry, open, south-facing slopes dominated by *Carex siccata* Dewey with *Calamagrostis purpurascens* R. Brown and many other native species of dry, open ground, including *Agrostis scabra* Willdenow, *Arabis holboellii* Horne-

man, *Anemone multifida* Poiret and *Pinus banksiana* Lamb. It was also found on top of a rocky ridge E of Yellowknife. This was also a natural, open and rather dry plant community dominated by native species, including *Androsace septentionalis* L., *Arctostaphylos uva-ursi* (L.) Spreng., *Artemesia hyperborea* Rydb., *Calamagrostis purpurascens* R. Br., *Carex supina* Willd., *Juniperus communis* L., *Juniperus horizontalis* Moench, *Rosa acicularis* Lindl., *Saxifraga tricuspidata* Ait. and *Senecio pauperculus* Michx. The flora was entirely native and had not been disturbed by man. Consequently *Chenopodium leptophyllum* is considered native.

Eleocharis erythropoda Steudel
BALD SPIKE-RUSH

Frequent on the periodically flooded shore of the Hay River at Hay River, this native plant was reported for the Northwest Territories by Smith et al. (2002) but accidentally omitted from the recent compilation of additions (Catling et al. 2005*) so included here. It differs from *E. palustris* (L.) Roemer & Schultes by the basal scale completely or nearly surrounding the stem (instead of encircling only 2/3) and relatively narrow stems 0.3-1.4 mm thick (instead of 0.5-5 mm thick). See under *"Panicum capillare"* for associated species.

Galium aparine L.
CLEAVERS

Found in vacant lots and disturbed open places in Yellowknife, this species differs from *G. triflorum* by the retrorse barbs on leaves and stems. There are possibly both native and introduced races; the plant of open disturbed sites is probably introduced.

Malva neglecta Wallr.
DWARF MALLOW

A few plants of this introduced species were found in vacant lots in Yellowknife. This is the first report of a species of *Malva* in NWT. The rounded leaves and axillary flowers with petals twice as long as the sepals are distinctive.

Panicum capillare L. var. *occidentale* Rydberg
COMMON PANIC GRASS

This is the first report of a species in this genus for NWT. The exerted panicles and long-acuminate spikelets, many with pedicels shorter than the spikelet, suggested var. *occidentale*. The plants were sporadic on the periodically flooded shore of the Hay River at Hay River. A native species, it often occurs in disturbed sites and is sometimes thought to be an introduction, but on the periodically flooded shoreline it occurred with a diversity of native species in one of its characteristic natural habitats. Close plant associates included *Aster modestus* Lindl., *Caltha natans* Pall., *Carex sychnocephala* Carey, *Cicuta maculata* var. *angustifolia* Hook., *Deschampsia caespitosa* (L.) Beauv., *Eleocharis erythropoda* Steud., *Galium triflorum* Michx., *Gnaphalium uliginosum* L., *Juncus nodosus* L., *Limosella aquatica* L., *Poa palustris* L., *Potentilla anserina* L., *Ranunculus scleratus* L., *Ranunculus macounii* Britt., *Rorippa palustris* (L.) Besser, *Rumex maritimus* L., *Schoenoplectus pungens* (Vahl) Palla, *Scirpus microcarpus* Presl and *Spartina gracilis* Trin.

Schoenoplectus pungens (Vahl) Palla
(*Scirpus americanus* auct. non Persoon)
COMMON THREE-SQUARE BULRISH

This native plant was frequent along the periodically flooded shore of Hay River at Hay River. It is distinctive in the lateral (instead of terminal) inflorescence with stemless spikelets and the sharply three-angled stems. This occurrence may be an extension of known range of approximately 700 km based on Packer's (1983) map. See under *"Panicum capillare"* for associated species.

Silene cserei Baumg.
BALKAN CATCHFLY

Found along the railway and in adjacent open sandy soil at port of Hay River, this tall introduced species (2-8 dm) has 3 styles, lacks glutinous bands on the stem and is without an inflated calyx.

Symphyotrichum lanceolatum (Willd.) G. L. Nesom subsp. *hesperium* (Gray) Nesom var. *hesperium* (*Aster lanceolatus* Willd. subsp. *hesperius* (A. Gray) Semple & Chmielewski, *Aster hesperius* A. Gray)
WESTERN WILLOW ASTER

This native plant was found on the periodically flooded shore of Hay River at Hay Riverand at the port of Hay River. At least 100 plants were seen and they had either white or blue ray flowers. This species has green leaves 5-15 mm wide instead of purplish-green leaves less than 5 mm wide as in *A. borealis* (T. & G.) Prov. (previously *A. junciformis* Rydberg). Unlike *A. spathulatus* Lindley, the stems are pubescent. This species is well known from the Lake Athabasca area of northern Alberta.

Additional Notes

Sonchus arvensis L. subsp. *uliginosus* (Bieb.) Nyman (*S. arvensis* var. *glabrescens* Guenth., Grab. & Wimmer, *S. uliginosus* Bieb.)

This introduced species is frequent in disturbed sites at Hay River and Yellowknife, but is not an addition because the inclusion of *"Sonchus arvenvis* L." in Porsild and Cody (1980) is not based on material of subsp. *arvensis* but rather on material referable to this variety (based on examination of specimens collected at Hay River (*Cody 14839*, DAO) and on the Mackenzie highway (*Thieret 6172*, DAO).

Acknowledgments

Suzanne Carriere, Ecosystem Management Biologist, Wildlife & Fisheries Division, Department of Resources, Wildlife & Economic Development, provided extensive help and support. Bill Cody, Curator Emeritus, with AAFC in Ottawa provided essential information and comments on the manuscript. Deborah Johnson and Mike Fournier assisted with plant collecting.

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Received 31 March 2005
Accepted 1 September 2005

Notes

Possible Tool Use by Beavers, *Castor canadensis,* in a Northern Ontario Watershed

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Barnes, D. M. 2005. Possible tool use by Beavers, *Castor canadensis,* in a northern Ontario watershed. Canadian Field-Naturalist 119(3): 441-443.

At a remote active Beaver (*Castor canadensis*) dam site in the Chapleau Crown Game Preserve of northern Ontario, I noted an instance where a Beaver had used a willow stem as a prop to allow it to cut other willow stems at an unrealistic height. The use of this tool (prop) meant less land foraging that in turn reduced the risk of predation and prevented undue thermal stress. This is the first account in the literature of a Beaver possibly using a tool to aid in foraging.

Key Words: Beaver, *Castor canadensis*, boreal forest, foraging, tool use, Ontario.

Tool use has long fascinated behavioural scientists involved in understanding animal evolution (Washburn 1960; Lancaster 1968). Over the years, researchers have documented the use of tools in insects (Wilson 1975), birds (Lack 1947; Chisholm 1954; van Lawick-Goodall and van Lawick-Goodall 1966; Morse 1968; van Lawick-Goodall 1970; Anderson 1989; Marks and Hall 1992), and mammals (Kortland 1962; van Lawick-Goodall 1968; van Lawick-Goodall 1970; Chevalier-Skolnikoff and Liska 1993; Hart and Hart 1994; Tokida et al. 1994).

Scientists have recognized that Beavers (*Castor canadensis*) have the ability to construct elaborate dams, lodges, and canals. Despite these achievements, there has been only one example of tool use documented in the literature. While studying two captive Beavers at the Berne Brain Anatomy Institute, Pilleri (1983) documented an ingenious example of tool use. He kept Beavers in a concrete pool that had a constant supply of fresh water. The overflow from the pool went into a vertical metal pipe via three 0.8 cm holes. From a supply of twigs left for their use, the Beavers successfully cut three sticks to exact dimensions and wedged them into the three outflow holes completely stopping the flow of water.

In 1993, while conducting research on Beavers (Barnes and Mallik 1996, 1997, 2001), I documented another possible example of Beaver tool use. At a remote active Beaver dam site within the Swanson River drainage area of the Chapleau Crown Game Preserve (CCGP), 48°04'N, 83°15'W of northern Ontario (Barnes and Mallik 2001), I found a willow (*Salix* spp.) clump which had stems cut at a height of approximately 1 m above the ground (Figure 1). This is an extraordinary height considering that Beavers, on average, cut at an average height of 30 cm above the ground (Johnston

Figure 1. A photograph showing the Beaver's use of a willow stem as a prop to enable cutting at the elevated height above the ground. The prop is the centrally located, lighter-coloured stem supporting the camera lens cap (diameter – 6 cm). Note that the Beaver has cut both the upper and lower ends of the prop; the lower end cut is hard to see due to ground cover. Unfortunately, the photograph does not show the 45° leaning angle.

and Naiman 1990; Barnes and Mallik 1997). I made a careful examination of the area and found that there was no apparent way that Beavers could have cut the stems at such a height. When I studied the willow clump more closely, I noted that there was a freshly cut willow stem, approximately 12 cm in diameter, leaning against the main stem of the willow clump; its approximate angle was 45° (Figure 1). In addition, I observed cutting at both ends of the leaning willow segment. I first thought that the stem had fallen into place. However, this explanation does not seem possible for three reasons. First, the willow stem would have to have fallen from the overhead clump and lodged in a leaning position. When one compared colour and texture of bark, the leaning willow segment was clearly different from the stems of the willow clump (Figure 1). Second, even if we assume the willow segment came from the clump, it would have to fall from a height in order to land in the proper position. From Figure 1, cuts directly above the leaning willow are clearly too high for Beavers to harvest from ground level; i.e., approximately 1 m. Third, the fallen stem would have had to land exactly into the correct position; i.e., 45° angle and distance of 45 cm below the cut stems of the willow clump (Figure 1).

Another possible explanation as to why Beavers were able to cut stems at such a height may have something to do with snow levels. Northern Beavers in the late winter and early spring will often forage over snow in order to obtain fresh food along impoundments and streams (Mech 1966; Peterson 1977). To gauge the reliability of this probable scenario, one must have a better appreciation for the general area. The dam itself was 118 m in length and a height of 1 m. The willow clump was located a distance of approximately 10 m downstream from the dam. I noted that the overflow from the dam created four smaller streams; the largest of these had an average width and depth of 1.6 m and 0.17 m, respectively. In my opinion, if Beavers were to exit the waterway in winter, their most optimal strategy would have been to utilize the impoundment edge. Rue (1964) noted that in winter, water levels in Beaver impoundments often become reduced leaving air pockets along the shore, and these become convenient places for Beavers to access land. To travel overland to the willow clump the Beaver would have had to climb over the dam and wade through deep snow for 10 m, as the downstream water channels were too small to afford any great advantage. This choice would be highly unrealistic. Barnes and Mallik (2001) showed that in the ice-free seasons, these northern Beavers forage for food trees in close proximity to water. Their study showed that Beavers harvested 71% of Trembling Aspen (*Populus tremuloides*) stems within 10 m of the impoundment edge. Beavers restricted their foraging range because of the risk of predation by Gray Wolves (*Canis lupus*) (Barnes and Mallik 2001).

In response to this perplexing situation, I propose an alternative explanation. I believe that a Beaver deliberately cut and transported a willow stem segment and placed it against the main stem of the willow clump. This prop enabled the Beaver to establish an elevated foraging position that facilitated the cutting of narrower stems located above the thickened stems of the clump. However, this reasoning does not explain how Beavers were able to harvest some of the highest stems (Figure 1). Like Rue (1964), I have noticed some instances where Beavers have shown surprising climbing agility. I, therefore, believe that these Beavers may well have used this prop in conjunction with other clump features to establish elevated platforms from which to cut (Figure 1).

This type of behaviour is characteristic of tool use as reported in the literature. In his treatise on the evolution of tool use in feeding animals, Alcock (1972) characterizes tool use as the manipulation of an inanimate object that improves the organism's efficiency in altering the position or form of some other object. Further, the organism should not be able to manufacture the object internally. Recently, Michener (2004) found that North American Badgers (*Taxidea taxus*) facilitated the capture of Richardson's Ground Squirrel (*Spermophilus richardsonii*) by using soil to plug their tunnels. In like manner, by using the cut stem as a prop, the Beaver was able to gain a better position to cut the higher positioned narrow willow stems. Clearly, the propped stem afforded the Beaver a platform with an optimal foraging height.

This observation is significant for two reasons: (1) this account represents the first documented case of Beavers using a tool to facilitate foraging activity; and (2) the use of a tool, from an optimal foraging perspective, provided the Beaver with an ecological advantage by reducing the foraging time on land. In boreal situations, such as the CCGP, a lessening of foraging time means reduced exposure to Gray Wolves. Potvin et al. (1992) demonstrated that Gray Wolves are highly effective predators. In subsequent studies, Basey and Jenkins (1995) further showed that Beavers actually trade off maximum profitability against minimization of Wolf predation. In addition, Beavers experience thermal stress with prolonged exposure to overland foraging activity (Barnes and Mallik 2001).

Acknowledgments

I acknowledge the financial assistance of Ducks Unlimited, the Ontario Ministry of Universities and Colleges, and Environmental Youth Corps. I am indebted to A. Mallik, Department of Biology, Lakehead University and C. Todesco of the Ontario Ministry of Resources for their guidance and logistic support. I am grateful to F. DeGagne for his technical assistance during the field work. In addition, I thank B. Barnes, Department of Biology, Lakehead University for her proof-reading skills.

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Received 1 October 2002
Accepted 30 June 2005

Predation of a Bat by American Crows, *Corvus brachyrhynchos*

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Lefevre, Kara L. 2005. Predation of a bat by American Crows, *Corvus brachyrhynchos*. Canadian Field-Naturalist 119(3): 443-444.

This report documents predation and possible group hunting of a bat by American Crows (*Corvus brachyrhynchos*). I observed a group of several crows appear to cooperate in order to ground and catch a bat. Predation of bats by birds in North America is relatively rare, and bat predation by crows has not been previously reported. A cooperative attack would be consistent with other group behaviours of the species, including territoriality, breeding and foraging.

Key Words: American Crow, *Corvus brachyrhynchos,* bats, Chiroptera, *Myotis lucifugus*, predation, Ontario.

Several bird species are known to feed occasionally on bats—mainly birds of prey, but also members of families Laridae and Corvidae, among others (Speakman 1991; Radzicki et al. 1999; Lee and Kuo 2001). The omnivorous American Crow (*Corvus brachyrhynchos*) is one of North America's most widespread birds (Verbeek and Caffrey 2002). This opportunistic species is known as both a scavenger of anything edible and a predator of diverse taxa, including small mammals (e.g., Nocera 2000; Verbeek and Caffrey 2002). To my knowledge the incident reported here is the first published record of bat predation by *C. brachyrhynchos*.

I observed an episode of bat predation by American Crows along the Rideau River in Ottawa, Ontario (45°19'N, 75°40'W) on 18 April 1996 at 17:45 EST. Visibility was excellent due to the absence of foliage following winter. I noticed a group of eight crows perched approximately 10 m high, at the edge of a deciduous woodlot beside the river. The woods bordered on an open field of dead grass. Four of the eight crows remained perched while the rest became involved in a chase of a small bat (Order Chiroptera) about the size of a sparrow. Based on size and relative species abundances it was possibly a Little Brown Bat (*Myotis lucifugus*), but seven bat species that occur in the area fit the size description (A. J. Erskine and S. Peters, personal communication). Mid-April is early in the season for bat activity in eastern Ontario: *M. lucifugus* females leave the hibernacula at this time and fly to the nurseries, while males remain torpid until mid-May (Gerson 1984).

During the chase the bat flew jerkily in different directions, approximately 5–7 m above the ground, eluding capture by 1–3 crows that chased it at any given time. Each time crows approached closely the bat dropped in altitude, effectively evading them. The crows attempted to use their bills but not their feet to strike the bat. The bat seemed to escape after three minutes of this activity, and the crows stopped chase for a brief time. One crow then darted after the bat and two others followed. Two of the three crows moved in and appeared to "sandwich" the bat about 3 m above the ground. They likely struck the bat because it dropped suddenly to the ground, with the third crow in pursuit. The three crows immediately moved to the ground: one struck the bat hard enough to make it pop up into the air above their heads, and then picked the bat up in its bill. There was no apparent dispute for possession of the bat. The three crows flew up to where the others were perched; the captor and another of the chasers landed in the same branch, and then the captor flew approximately 50 m South along the edge of the words to a new perch, also 10 m above the ground. The bat was still in its bill and none of the other crows followed. The captor attempted awkwardly to bite/peck at the bat held in its feet. After one minute at this new perch, the captor flew beyond view with the bat in its bill. The other crows remained in the original area, some perched in the trees and others in the field near where the bat had been grounded.

These observations may represent an episode of cooperative hunting. Hendricks and Schlang (1998) reported similar cooperative aerial attacks by the congeneric Common Raven (*C. corax*) on adult pigeons. Such group hunting by *C. brachyrhynchos* would be consistent with adaptive cooperation observed in this species including group territoriality (Caccamise et al. 1997), cooperative breeding (Caffrey 1992), and group foraging (Kilham 1989; Verbeek and Caffrey 2002). The absence of any apparent competition for the captured bat suggests that the captor could have been an adult crow with the other participants being immature. Alternatively, it is also possible that this was an instance of several crows attempting to hunt the same bat individually, without any real cooperation.

This observation is noteworthy because direct predation events are seldom observed, predation of bats by birds in North America is apparently rare, and because this is the first account of American Crows hunting bats. Based on a review of the impact of bird predation on bat mortality (Speakman 1991), it is unlikely that crows pose any significant predation threat to North American bat populations.

Acknowledgments

I thank A. J. Erskine, Sandra Peters, and one anonymous reviewer for comments that improved the manuscript.

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Received 1 July 2004
Accepted 2 September 2005

Mortality of Deer Mice, *Peromyscus maniculatus*, in Wire Mesh Live-Traps: A Cautionary Note

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Jung, Thomas S., and Kieran S. O'Donovan. 2005. Mortality of deer mice (*Peromyscus maniculatus*) in wire mesh live-traps: a cautionary note. Canadian Field-Naturalist 119(3): 445-446.

Live-capture of animals occasionally results in the death of some individuals. Here, we report upon an unusual occurrence of trap-related mortality observed in Deer Mice (*Peromyscus maniculatus*) captured in wire mesh live-traps during field sampling in southeastern Yukon. Eight of 85 marked individuals (9.4%) were found with their snouts caught in the wire mesh of our live-traps; four of these individuals were found dead. We suggest a modification to Ugglan live-traps that would likely decrease such incidents.

Key Words: mortality, Deer Mouse, *Peromyscus maniculatus*, Live-trapping, Yukon.

Biologists often rely upon data obtained through the live-capture of individuals. Field sampling of animal populations and communities, however, occasionally results in the death of some individuals. Mortality can compromise data collection when experimental designs require individuals to be live-captured, marked and, later, recaptured. When deaths are the result of equipment or technique then it is incumbent upon field researchers to share this information and seek means to reduce capture mortality, for both ethical and data collection reasons (e.g., Jung et al. 2002). Here, we report upon an unusual incident of trap-related mortality of Deer Mice (*Peromyscus maniculatus*) during field sampling in southeastern Yukon.

As part of a study of small mammal communities in the boreal forest near Watson Lake, Yukon (60.06° N, 128.70° W), we used Ugglan live-traps (Model 3 Lemming Special, Granhab, Marieholm, Sweden) to live-capture small mammals during September 2003. Unlike some other commonly used types of small mammal live-traps like Sherman traps (H. B. Sherman Traps, Tallahassee, FL) or Longworth traps (Longworth Scientific Instruments Co., United Kingdom), Ugglan traps are constructed of wire mesh and the trap door is elevated and gravity controlled (as opposed to spring loaded). Our traps measured 250 × 78 × 65 mm and had a 6 × 6 mm wire mesh around the top and sides of the trap. A weather shield made of sheet metal covered most of the wire mesh.

We captured 85 individual Deer Mice 167 times during our study. Eight individuals (9.4% of individuals captured) were found with their snouts caught in the wire mesh of the traps (Figure 1). Because their upper incisors were through to the other side of the mesh, they were unable to free their snouts and they were lacerated on both sides of the snout. Four were found dead. We released the four live individuals but they did not appear to be in good condition upon release; we did not recapture these four individuals and suspect from their injury and constitution that they may have died sometime after release. All of the individuals that were encountered with their snouts stuck in the wire mesh were found underneath the elevated trap door (Figure 1), where the animals could see outside of the trap. We surmise that trapped Deer Mice were attempting to gnaw through the exposed wire mesh to escape and became caught. No other Deer Mice were found dead in the traps other than those with their snouts caught.

FIGURE 1. Deer Mouse with its snout caught in the wire mesh of an Ugglan live-trap. The tin weather shield was removed for this photograph.

During our sampling, we captured 443 individuals, representing five species (Deer Mice and 4 species of arvicoline rodents), a total of 888 times. None of the voles captured (Northern Red-backed Vole, *Clethrionomys rutilus*; Long-tailed Vole, *Microtus longi-*

caudus; Meadow Vole, *M. pennslyvanicus*; Taiga Vole, *M. xanthognathus*) captured were found with their snouts stuck in the wire mesh. Although some voles (12.9%, primarily juvenile *C. rutilus*) died in the traps from exposure, predation, or stress-related capture myopathy, we do not attribute this to trap type or technique. We suggest that voles did not become entrapped like some Deer Mice because of the difference in their facial morphology; arvicoline rodents tend to have shorter and broader snouts than mice, thus their snout likely would not fit through the wire mesh of our live traps.

The percentage of Deer Mice killed in our Ugglan traps is higher than reported in other studies of *Peromyscus*. For example, Whittaker et al. (1998) reported that <1% (2 of 655) of *Peromyscus* (White-footed Mouse, *P. leucopus* and Cotton Mouse, *P. gossypinus*) captured had died in box-style (Sherman) traps. In Australia, Jacob et al. (2002) reported mortality rates of House Mice (*Mus domesticus*) in Ugglan traps as 12%, wheras mortality in Longworth traps was only 1%. They attributed mortality of house mice in Ugglan traps to exposure, however, and not to becoming caught in the wire mesh.

This report of an unusual cause of trap-related mortality of Deer Mice in wire mesh traps is not intended to be a critique of wire mesh traps (which some believe to be a superior trap for some species of small mammals; e.g., O'Farrell et al. 1994). Rather, we wish to alert biologists intending to use similar traps of a potential problem.

A smaller mesh size would likely prevent such mortalities, but may be prohibitive to manufacture and would not address the use of those traps already in field use. We suggest that biologists using Ugglan traps can reduce the incidents of this type of trap mortality by slightly modifying the traps. A small piece of cardboard or tin can be placed to cover the wire mesh under the trap door without affecting it's operation. This would likely reduce trap-related mortalities of mice and may also keep bait from sliding outside of the capture area. We note that some Ugglan traps came supplied from the manufacturer with such a tin shield, while others did not.

Acknowledgments

We thank C. Gagnon, V. Loewen, and J. Staniforth for field assistance. J. Adamczeski, V. Loewen, D. Nagorsen, M. O'Donoghue, B. Slough and an anonymous reviewer kindly suggested improvements to this note. Funding for the study that yielded these observations was provided by the Yukon Department of Environment.

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Received 13 November 2003
Accepted 15 February 2005

Longevity and Productivity of Three Wolves, *Canis lupus,* in the Wild

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Holyan, Jim, Diane K. Boyd, Curtis M. Mack, and Daniel H. Pletscher. 2005. Longevity and productivity of three Wolves, *Canis lupus*, in the wild. Canadian Field-Naturalist 119(3): 447-448.

We document longevity and productivity of three Wolves (*Canis lupus*) in the wild in Montana and Idaho, USA. Two male Wolves each attained ages of at least 13 years, while a female was 12.2 years old. All three Wolves in our study were older at the time of their last known reproductive events than others reported in the literature.

Key Words: Wolf, *Canis lupus*, longevity, reproduction, Montana, Idaho.

Wolves (*Canis lupus*) are a relatively long-lived species, with individuals in captivity commonly reaching 9+ years, and occasionally living up to 17 years. (Young and Goldman 1944; Goodwin and Ballard 1985; Okarma and Koteja 1987; Mech 1988; Landon et al. 1998; Mech and Boitani 2003). Mech (1988) stated that wild Wolves rarely exceed 13 years of age, and Peterson (1997:13), referring to the protected Wolf population in Isle Royale National Park, stated that maximum lifespan could reach "10-12 or even 14 years," though his statement was not supported with documentation. It is reasonable to assume that Wolves

living in captivity would outlive wild Wolves facing more rigorous environments.

Here, we report on three wild Wolves, 9013, 8756, and B-2, that each attained an estimated minimum age of 12.2 years. These animals were all radio-collared and inhabited Idaho and Montana, USA, from 1987 to 2004. Data for these Wolves were collected using standard radio-telemetry techniques in the Northern Rocky Mountain recovery areas of the USA (U.S. Fish and Wildlife Service et al. 2004).

Ages of Wolves can be accurately determined for individuals < 2.5 years old based on tooth eruption and wear patterns (Gipson et al. 2000), body size, development and appearance of external reproductive organs, and previous known pack history. Using these criteria, and assuming a mid-April birth date (Boyd et al. 1993; Thurston 2002), we were able to determine the ages for male Wolf 9013 and female Wolf 8756 at the times of their captures. We were only able to estimate male Wolf B-2s age because he was greater than 2.5 years old at the time of his capture.

Male Wolf 9013 was initially captured and radio-collared in September 1990 as a member of the South Camas pack in Glacier National Park, Montana, USA. We determined he was 2.4 years old at the time of his capture. Wolf 9013 dispersed from his natal pack in 1991 to the Kelly Creek drainage of northern Idaho where he remained a lone wolf. In 1995, 15 Wolves were translocated into central Idaho as part of a federal strategy to recover endangered Wolf populations in the Northern Rocky Mountains of the USA (U.S. Fish and Wildlife Service 1994*). By March 1996, Wolf 9013 paired had with female Wolf B-15, one of the Wolves translocated in 1995. They produced a litter of five pups in 1997 and formed the Kelly Creek pack when Wolf 9013 was 8.8 years old. This breeding pair produced subsequent litters in 1998-2000. Wolf 9013 was 11.8 years old when he sired his final litter in 2000.

Wolf 9013 may have been displaced as the alpha male by late 2000, as he was frequently located apart from other radio-collared members of his pack. The Kelly Creek pack failed to reproduce in 2001. Wolf 9013 was 13.2 years of age when he died from unknown causes in June 2001. An incisor was collected for aging (Goodwin and Ballard 1985). Cementum annuli analysis (Matson's Laboratory, LLC) indicated an age of 8-9 years for Wolf 9013, which underestimated the known age by a minimum of 4.2 years, the error probably caused by extensive cementum resorption (G. Matson, personal communication).

Female Wolf 8756 was captured in Glacier National Park, Montana, USA, as a 5-month-old pup in October 1987. She was monitored weekly with radio-telemetry from 1987-1999. She became the breeding female of the South Camas Pack in Glacier National Park in 1990 at the age of 2.8 years. She apparently produced a litter of pups every year and possibly produced her last litter at 12 years of age. She was 12.2 years of age at the time of her death in June 1999 (Gipson et. al. 2002).

Male Wolf B-2 was estimated to be 4.8 years old when translocated to central Idaho during the federal recovery effort in 1995. Wolf B-2 paired with a dispersing female Wolf and established the Wildhorse pack, where he fathered litters of pups in 2000 and 2001, at the approximate ages of 9.8 and 10.8 years, respectively. He also sired a litter of four pups in 2003 at approximately 12.8 years of age, after he established the Castle Peak pack. He died at the estimated age of 13.8 years in February 2004. A lower first premolar was collected for aging (Goodwin and Ballard 1985). Cementum annuli analysis (Matson's Laboratory, LLC) indicated an age of 11 years for Wolf B-2.

The two male Wolves reported here lived longer than other longevous wild male Wolves reported in the literature; 9013 was 13.2 years old and B-2 was estimated at 13.8 years old. Mech (1988, 1997) reported minimum ages of 11.6 and 11.0 years for the two oldest males he studied. Female Wolf 8756 outlived all but one wild female Wolf reported by Mech (1988).

Both males 9013 and B-2 sired litters at older ages than others reported in the literature. Mech (1988) noted the oldest male Wolf in Minnesota that sired pups was 10.8 years of age; Wolf 9013 was 11.8 years of age in 2000 when he was still believed to be the breeding male of his pack. Wolf B-2 was an estimated 12.8 years old when he was known to be the breeding male of his pack.

Kreeger (2003:193) stated "maximum breeding age for female wolves is not known." Female Wolf 8756 exceeded the maximum breeding age previously reported when she produced pups at 11 years of age, and she may have reproduced at 12 years old.

The value of known-age animals is significant in describing longevity. Estimating age with cementum annuli analysis may not be accurate for Wolves (Goodwin and Ballard 1985; Landon et al. 1998). Gipson et al. (2000) concluded that cementum annuli analysis underestimated actual age by 1-3 years for Wolves >3-14 years of age. Our longevity data for two Wolves of known age and a third with a good age estimation, and their reproductive activity at advanced ages, are noteworthy.

Acknowledgments

The University of Montana, the U.S. Fish and Wildlife Service, the National Park Service, and the Nez Perce Tribe supported this study. We thank I. Babcock, M. Carter, A. Sondenaa, and two anonymous reviewers for comments that improved this manuscript.

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Received 10 May 2004
Accepted 6 June 2005

Observations of Autumn Courtship and Breeding in Brown Bears, *Ursus arctos*, from Coastal British Columbia

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Over a period of four years, autumn courtship behaviour in Brown Bears (*Ursus arctos*) was observed on three separate occasions, with copulation observed once and two litters of cubs potentially resulting from autumn breeding. These are the first recorded observations of these behaviours.

Key Words: Brown Bear, *Ursus arctos*, reproduction, autumn, courtship, mating, British Columbia.

Brown Bears (*Ursus arctos*) mate in the spring from May to July. Once the fertilized eggs have developed to the blastocyst stage, further development is delayed until just before denning, typically November. At this time the blastocysts implant and a short pregnancy ensues with one to four cubs born during winter sleep, usually in February. This delayed implantation leads to an apparent gestation period of 6.5 – 8.5 months, although embryonic development occurs only in the last 6 – 8 weeks (Craighead et al. 1969; Hensel et al. 1969; Garshelis 2001).

Between August 1999 and May 2003, Brown Bears in the Glendale Cove area of British Columbia (50°41'N 125°44'W) were individually identified and observed as part of an ongoing study (Nevin 2003). Photo-identification techniques allowed individual bears to be distinguished. Coat coloration and scar patterns were recorded with sketches and descriptions on data sheets, supplemented by a catalogue of reference photographs. Each bear was given a unique numeric code. Sex was determined by urination pattern, direct observation of genitals or the presence of cubs (Nevin 2003; Nevin and Gilbert 2005a).

Autumn courtship was first observed in mid-September 1999; two large adult males (M003 and M004) were observed tracking a lone female (F005). While this close following and olfactory investigation of urine is typical of the breeding season, it was only in light of subsequent observations that this was recognized as out-of-season courtship behaviour.

Two weeks later, at the beginning of October 1999, one of these male bears (M003) was observed courting another lone female (F102). During the 40 minutes that the interactions of these bears were recorded, tracking was again observed; in addition, there was play fighting, genital sniffing and mounting.

In the same week one of the female bears (F009) lost two yearling cubs. The cubs were last seen on 3 October 1999 after which F009 was seen alone. F009 is a highly identifiable bear with distinctive scarring and a muzzle that twists to the right. After the loss of her cubs in 1999 she was not seen in 2000 but returned to the Glendale spawning channel in early September 2001. At this time she was accompanied by three yearling cubs; these cubs would have been born during the 1999-2000 hibernation. For this to happen, F009 must either have mated in the spring of 1999 while still with her yearling cubs or have mated in the autumn of 1999 after the loss of her cubs. Neither explanation would be considered typical behaviour.

In mid September 2001 M004 was again seen tracking F005; this is the same pairing seen in September 1999 and F005 still had no cubs. On this occasion they approached another female (F103) and her two-year-old cubs. F103 charged F005 and after a brief agonistic interaction F005, the larger of the females, backed away approximately 10 m and sat down. At this point F103 was approached by M004; after another brief agonistic interaction, F103 moved away from her cubs and offered no resistance to mounting by M004. Copulation began immediately and continued for at least 10 minutes at which time continued observation became impossible. This is the first recorded observation of autumn copulation in Brown Bears. It should be noted that F103 had been involved in courtship behaviour in the spring (e.g. 15 May 2001 with M301); she had separated from her cubs in late May and was seen mating with M301 in May and June. F103 and cubs had reunited by 16 September 2001. F103 was seen in May 2002 with two young-of-year cubs but it is not known whether these are from spring or autumn mating in 2001.

With only four observations over a period of four years during which 341 days of systematic behavioural observations were conducted for ongoing research projects (Nevin 2003; Nevin and Gilbert 2005a, b) on the approximately 40 individual bears using the area, we are clearly discussing rare events; during this period more than 30 breeding events were observed during the spring breeding season. It should be noted that although all the observations of autumn courtship and breeding involve one of two male bears (M003 and M004) these were two of the five largest males in the area.

Very little is known about the reproductive biology of any bear species and new insight into Brown Bear

breeding may have impacts on the conservation and management of other bear species, many of which are threatened or endangered (Spady 2002). The potential of successful autumn breeding will also add a new dimension to the ongoing debate on infanticide in Brown Bears (Wielgus et al. 2000, 2001; Swenson et al. 2001a, b; Dahle and Swenson 2003; Miller et al. 2003; Ben-David et al. 2004; Nevin and Gilbert 2005a, b). With the possibility of same-season breeding opportunities associated with cub-killing events throughout the non-denning period, the selective advantage associated with this behaviour would be much higher than it has been assumed to be under the prevailing view that breeding is restricted to the spring period.

Acknowledgments

This research was funded through ongoing support from Knight Inlet Lodge and the Glendale Grizzly Trust. Special thanks go to Barbara Bull, Dean Wyatt and the staff of Knight Inlet Lodge.

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Received 9 August 2004
Accepted 22 August 2005

Long-distance Movement of a Dispersing Deer Mouse, *Peromyscus maniculatus*, in the Boreal Forest

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Jung, Thomas S., Kieran S. O'Donovan, and Todd Powell. 2005. Long-distance movement of a dispersing Deer Mouse, *Peromyscus maniculatus*, in the boreal forest. Canadian Field-Naturalist 119(3): 451-452.

We report an apparent long-distance, non-homing movement of 3044 ± 60 m made by a dispersing subadult male Deer Mouse, *Peromyscus maniculatus*, in southeastern Yukon. Our observation is nearly twice the maximum distance previously recorded for non-homing Deer Mice, and apparently the longest dispersal movement recorded for this species.

Key Words: Deer Mouse, *Peromyscus maniculatus*, dispersal, movements, Yukon.

Despite the significance of dispersal in the spatial ecology and population dynamics of small mammals, the process is little understood (Fairbairn 1978; Bowman et al. 2001). Deer Mice (*Peromyscus maniculatus*) can move relatively long distances (e.g. >1000 m; Teferi and Millar 1993; Topping et al. 1997; Bowman et al. 1999, 2001; Rehmeier et al. 2004), yet reports of such movements are rare, likely due to a low probability of detection (Rehmeier et al. 2004). Here, we report an apparent record long-distance movement by a dispersing Deer Mouse in southeastern Yukon.

As a part of studies on small mammals in the boreal forest near Watson Lake, Yukon (60.06°N, 128.70°W), we used Ugglan live-traps (Model 3 Lemming Special, Granhab, Marieholm, Sweden) and Longworth live-traps (Longworth Scientific Instruments Co., Abingdon, United Kingdom) to live-capture small mammals during summer and fall 2004. We live-trapped rodents at two study areas situated about 3 km apart. One trapping area (Area A) was located about 1 km N of Watson Lake, while the other (Area B) was about 3 km NE of Watson Lake. Both study areas were in boreal mixedwood forest. Co-dominant tree species included White Spruce (*Picea glauca*), Lodgepole Pine (*Pinus contorta*), Trembling Aspen (*Populus tremuloides*) and White Birch (*Betula papyrifera*). Limited logging occurred in Area B 8-12 years prior to our trapping.

At Area A, we established 6 grids of 25 trapping stations (5 × 5 layout; 10 m between traps). We placed one Ugglan and one Longworth trap at each trapping station. Traps were operational for eight days with no pre-baiting. At Area B, we ran 14 grids of 48-49 trapping stations (6 × 8 or 7 × 7 layout; 12 m between traps). One Ugglan trap was placed at each trapping station. Traps on these grids were pre-baited for two days and operational for three days. At both study areas, traps were 12 m apart, baited with rolled oats, peanut butter and a slice of carrot, and cotton bedding was provided. Each morning, captured animals were identified, weighed, sexed, aged, ear-tagged with a Number 1 Monel tag (National Band and Tag Company, Newport, Kansas), and then released where they were caught.

On 11 August 2004, we captured a subadult male Deer Mouse (eartag # 1027) in a Longworth trap at Area A. On 26 August 2004, 15 days after being originally captured at Area A, the mouse was recaptured in an Ugglan trap at Area B. Geographic co-ordinates (± 30 m) of the original capture location and the last capture location were obtained with a global positioning system (GPS; Garmin International Inc., Olathe, Kansas). We used a geographic information system (GIS; ArcView GIS 3.2, ESRI, Redlands, California) to calculate the distance moved by the Deer Mouse. GIS analysis provided a straight-line distance of 3044 ± 60 m between the two capture locations. Travel by the Deer Mouse was most likely through continuous boreal forest. The straight-line movement, or substantial variations thereof, indicate that the movement between capture locations was neither hindered nor facilitated by apparent barriers (e.g., rivers) or travel corridors (e.g., powerlines or roads), respectively.

No other investigators had trapped and ear-tagged small mammals in the area in the past five years, so it is unlikely that the Deer Mouse was from another study. Furthermore, our ear tags were prefaced with the code "YTG" before the numbering, which is distinctive in the field. Similarly, we are confident that the tag was not confused with another Deer Mouse ear-tagged on the grid where it was last recaptured, since none of the other five Deer Mice captured at this grid had tag numbers that were easily confused with # 1027. We did not simultaneously trap at both study areas, and different field crews were doing the work at the two study areas, so we consider it unlikely that the mouse traveled in a vehicle or trap with a field crew from Area A to Area B. Given rejection of these potential alternatives, we conclude that the Deer Mouse did, in all likelihood, move a minimum distance of 3044 ± 60 m.

Bowman et al. (1999) recorded a long-distance dispersal movement of 1768 m by a subadult male Deer Mouse in forests in New Brunswick. In Kansas, Rehmeier et al. (2004) reported several Deer Mice mov-

ing > 1000 m, with a maximum recorded movement of 1320 m. During homing experiments, several studies have reported human-induced movements of Deer Mice >1500 m (Murie 1963; Furrer 1973; Teferi and Millar 1993). In Alberta, Teferi and Millar (1993) reported one Deer Mouse had moved a straight-line distance of 1980 m during a homing experiment. Maier (2002) reported a female White-footed Mouse (*Peromyscus leucopus*) naturally moving a minimum of 14730 m, and another female White-footed Mouse moving 6840 m, between successive capture locations in Massachusetts. Therefore, our observation of a minimum movement of >3000 m for a Deer Mouse is not inconceivable. To the best of our knowledge, our observation establishes the longest recorded movement of a Deer Mouse.

Given the time of year (early fall) and that the individual was a subadult male, we suggest that the observed movement represents dispersal from the natal range (Fairbairn 1978). The mechanisms behind dispersal in *Peromyscus* are unknown. Rodent populations may vary widely from year to year (e.g., Gilbert and Krebs 1991), and Bowman et al. (1999) and Maier (2002) had suggested that long-distance dispersal in *Peromyscus* in their study areas may have been influenced by high population densities. In our study, however, Deer Mouse abundance was 3.4 times lower in 2004 than in 2003; 2.01 individuals per 100 trap nights (TN) vs. 6.77 individuals per 100 TN, respectively (Jung et al. unpublished data). Therefore, there should have been much nearby, suitable, and unoccupied habitat for the Deer Mouse to establish a territory. Rehmeier et al. (2004), using multiple observations over nine years, also noted an inverse relationship between population density and propensity of Deer Mice to move long distances. They suggested that increased numbers of social fences at higher densities may result in decreased incidences of long distance movements by Deer Mice. Maier (2002) suggested that a lack of traditionally available food resources may also lead to notably long-distance dispersal. We have no data on food availability for murine rodents in our study area. Regardless of the mechanism or trigger, our observation substantiates the contention by Bowman et al. (1999), Rehmeier et al. (2004), and Maier (2002) that small mammals may be more vagile than previously thought.

Acknowledgments

We thank K. Russell, J. Colbert, and R. Brodhagen for field assistance. M. O'Donoghue, B. Slough, D. Nagorsen and two anonymous reviewers kindly reviewed an earlier draft of this note. We thank the Yukon Department of Environment for its continued support of wildlife research.

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Received 17 September 2004
Accepted 8 September 2005

Movements of Two Rabid Raccoons, *Procyon lotor,* in Eastern Ontario

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Rosatte, Rick, Mike Allan, Rob Warren, Peter Neave, Todd Babin, Luke Buchanan, Dennis Donovan, Kirk Sobey, Chris Davies, Frances Muldoon and Alex Wandeler. 2005. Movements of two rabid Raccoons, *Procyon lotor,* in Eastern Ontario. Canadian Field-Naturalist 119(3): 453-454.

An adult female Raccoon *Procyon lotor* was captured about 3 km north of Mallorytown, Ontario, on 27 August 2004, as part of a government rabies control program. The animal was vaccinated against rabies, ear-tagged and released, and recaptured the next day 1.7 km south of the initial capture location. Upon recapture, the Raccoon had porcupine quills in its facial area and seemed agitated and was submitted for rabies testing. It was confirmed as rabies positive on 31 August 2004, by the Canadian Food Inspection Agency. Similarly, a juvenile male raccoon was captured, ear-tagged, vaccinated, and released near Junetown, Ontario (about 4 km NW of the other rabid Raccoon) on 5 September 2004. It was found dying in a residential window well on 22 September 2004, 700 meters from the original capture location. It was diagnosed as rabid on 23 September 2004.

Key Words: Raccoon, *Procyon lotor*, rabies, movement, disease transmission, Ontario.

The Raccoon, *Procyon lotor,* variant of rabies was first reported in Ontario, Canada, in July 1999 and 131 cases have been reported to September 2005 (Wandeler and Salsberg 1999; Rosatte et al. 2001). In response to these cases, the Ontario Ministry of Natural Resources (OMNR) implemented three different tactics to control the disease: Trap-Vaccinate-Release (TVR), Point Infection Control (PIC), and Oral Rabies Vaccination with baits (ORV) (Rosatte et al. 2001). The use of TVR involves live-capture (with humane cage traps) and vaccination with an injection of Imrab rabies vaccine (Merial, Athens, Georgia). Release of target animals such as Raccoons allows researchers to gain information on movements if the animals ear-tagged for identification during processing are recaptured. In addition, data regarding the movement of rabid Raccoons is scarce in the literature.

On 27 August 2004, an adult female Raccoon was captured (Tomahawk live-trap, Tomahawk, Wisconsin) (about 3 km north of Mallorytown, Ontario), as part of a TVR program in response to two cases of Raccoon strain rabies that had occurred near Mallorytown during mid-August 2004. This Raccoon appeared normal except it was vocalizing repeatedly with high-pitched whining sounds. A young female Raccoon was also captured at the same time about 2 meters from the adult female Raccoon and was probably one of her litter (as the adult female was lactating). Both Raccoons were ear-tagged, vaccinated against rabies (Imrab) and released at the point of capture. A Global Positioning System (GPS) reading (Magellan Trailblazer 300) was taken at the location where the animal was captured (430112E, 4927926N). The next day, 28 August 2004, the adult female Raccoon was recaptured at GPS 430094E, 4926235N, 1.7 km south of the initial capture location. On this occasion, the Raccoon was very agitated – constantly moving back and forth in the live-trap, turning upside down repeatedly, vocalizing with a high-pitched whine, and had three Porcupine, *Erethizon dorsatum*, quills in its facial area (snout). This Raccoon was humanely euthanized (via an injection) and submitted to the Canadian Food Inspection Agency, Ottawa Laboratory Fallowfield (CFIA OLF) in Nepean, Ontario, for rabies testing. Another lactating adult female Raccoon and two young female Raccoons were also captured at this time within 4 meters of the quilled Raccoon. These three Raccoons were ear-tagged, vaccinated against rabies with Imrab and released. The quilled adult female Raccoon was confirmed at CFIA OLF as positive for rabies on 31 August 2004. On 1 September 2004 the virus was determined at CFIA OLF to be the Raccoon variant of rabies.

On 5 September 2004, a juvenile male Raccoon was captured, ear-tagged, vaccinated, and released near Junetown, Ontario (about 4.2 km NW of the other rabid Raccoon at GPS 426300E 4928200N). The Raccoon appeared normal at the time. Several other Raccoons were also captured at this location. It was found dying in a residential window well on 22 September 2004, 700 meters from the original capture location. This raccoon was diagnosed as rabid on 23 September 2004.

Data regarding the movement of rabid Raccoons is critical when designing rabies control tactics, especially when determining the width of vaccination zones to contain the disease (Rosatte et al. 2001). Even less is known about the contact rates of rabid Raccoons with susceptible animals. These rates will, in turn, affect the intensity and movement of a rabies outbreak (Totton et

al. 2002). Due to the close proximity of the rabid Raccoon to the four other Raccoons that were captured, as well as the Porcupine quills in the rabid Raccoon (no rabid Porcupines have been reported in the area), there was great potential for this Raccoon to have transmitted rabies to multiple individuals, both intra-specifically as well inter-specifically, during its journey of at least 1.7 km (assuming the Raccoon moved in a straight line which is unlikely). Analysis of the mark-recapture data from the area in which the rabid Raccoon was captured indicated that the average Raccoon density was 10 raccoons/km^2. Given this high Raccoon density, the potential for rabies transmission to susceptible individuals in the area where the rabid Raccoon travelled was probably very high. This information was subsequently used to modify the OMNR's response to Raccoon rabies in eastern Ontario; the area where the rabid animal was captured was re-trapped and all abnormally acting Raccoons and Striped Skunks (*Mephitis mephitis)* were humanely euthanized and submitted for rabies testing. All animals that had been vaccinated during previous years were re-vaccinated against rabies and released.

Also of importance is the fact that both of these Raccoons were vaccinated against rabies, though vaccination did not protect them from developing clinical rabies. This in all likelihood was due to the fact that the first Raccoon already showed prodromal symptoms at the time of vaccination and the other Raccoon was incubating the disease. This emphasizes the value of Point Infection Control programs using population reduction around previous cases of rabies to remove clinical and incubating animals from the population — i.e., had population reduction been utilized instead of TVR both of these Raccoons would have been humanely euthanized and removed from the population negating any potential for them to infect other animals. On the other hand, population reduction would also have killed a large number of healthy animals that were already vaccinated against rabies from aerial baiting or previous TVR work. In this particular instance TVR provided valuable information, though euthanasia would have been the preferred disease control option. Obviously, both TVR and population reduction have their advantages when used for the control of wildlife rabies.

Acknowledgments

The Ontario rabies program is supported by the Provincial Rabies Advisory Committee, Dr. J. Carlson, Chair, and the Ontario Ministry of Natural Resources (OMNR), Wildlife Research and Development Section, Dr. C. Davies, Manager. Special acknowledgment goes to the staff of the OMNR, Rabies Research and Development Unit in Peterborough and the CFIA, OLF Rabies Laboratory, Nepean. This is OMNR Wildlife Research and Development Section contribution number 04-05.

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Received 27 September 2004
Accepted 6 September 2005

Common Loon, *Gavia immer,* Nest Attendance Patterns Recorded by Remote Video Camera

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Goodale, Wing, Lee Attix, and David Evers. 2005. Common Loon, *Gavia immer,* nest attendance patterns recorded by remote video camera. Canadian Field-Naturalist 119(3): 455-456.

We recorded the complete day/night nesting attendance of a Common Loon (*Gavia immer*) pair using a remote video camera. We found that the male and female share incubation duty equally, but that the female incubates primarily at night (95.8%) when the male defends the territory.

Key Words: Common Loon, *Gavia immer,* incubation pattern, sex, day, night, remote camera, Maine.

Researchers in the past have been limited to diurnal observations of Common Loon (Gavia immer) nesting behavior. Whereas many of those studies were conducted on unmarked loons (Sjolander and Agren 1972; Taylor 1974; McIntyre 1975), making the role of sex in incubation difficult to study, recent capture and marking techniques by Evers (1994, 2001) now allow researchers to determine the sex of the incubating birds. Past studies of nest attendance with marked birds have shown possible relationships between time of day and sex of the incubating bird. Paruk (2000) found that 23% of the time there was a least one nest switch during the night, suggesting nest exchanges may be "optimized" for males to patrol the territory at night. Gostomski and Evers (1998) found that males incubated twice as often in the evening and the females twice as often in the morning, indicating the pair switches incubation duty after sunset. Evers (1994) found no significant sex difference in incubation effort during daylight hours. Our study explored parental incubation patterns by using a remote video camera to record both day and night nest attendance of a marked Common Loon pair.

In 2001 the Common Loon pair on Coleman Pond, Maine (44°53'25", 70°45'32") was color-banded and sexed (through morphometric measurements) using body mass as the primary criterion (Evers 2004*). On April 2003 we set up a remote video camera equipped with a standard lens as well as a infrared lens and light for night vision (supplied by SeeMore Wildlife Systems) at a traditional nesting island in Coleman Pond, which is a single loon-territory lake. The camera, powered by solar panels, sent live images to a base computer and time-lapse VCR. At dusk the infrared light and lens would automatically turn on, allowing a recording of the entire incubation period. We then reviewed the time-lapse tapes and recorded (into a Microsoft Excel spreadsheet) the sex of the incubating bird (using the color bands) and the time of each nest exchange, as well as the amount of time the nest was left unattended. Events were not recorded after the eggs began pipping. Exact sunrise and sunset times for the lake were obtained from U.S. Navy records. From these data we calculated the precise time the male and female were on the nest during the day and night.

TABLE 1. Total hours and minutes of nest attendance by time of day and sex (percentage is in parentheses).

	Empty	Female	Male	Total
Day	30:30 (7.5)	97:08 (23.8)	280:58 (68.8)	408:36
Night	0:55 (0.5)	193:39 (95.8)	7:33 (3.7)	202:07
Total	31:25 (5.1)	290:47 (47.6)	288:31 (47.2)	610:43

Our results demonstrated that male and female loons shared incubation duty equally (Table 1). However, the female incubated the eggs primarily at night, whereas the male incubated primarily during the day. Gostomski and Evers (1998) interpreted that the male/female dusk and dawn nest attendance pattern indicated that the male defended the territory at night. That observation confirmed findings by McIntyre (1988), who suggested that during incubation males patrol the territory at night. Our results support those findings, and qualitative observations of the Coleman Pond loon pair indicated the male actively defended the territory at night from intruder loons with frequent yodel calls while the female was incubating.

Acknowledgments

We especially thank the MBNA Foundation, whose financial support made this project possible. In addition, Whitney and Tony Oppersdorff deserve special thanks for their generousity in providing a base station for the research equipment. Michelle Gharst also deserves special recognition for her review of the tapes.

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Received 8 November 2004
Accepted 30 August 2005

Short-tailed Shrew, *Blarina brevicauda*, Apparently Killed by Red Squirrel, *Tamiasciurus hudsonicus*

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Nero, Robert W. 2005. Short-tailed Shrew, *Blarina brevicauda*, apparently killed by Red Squirrel, *Tamiasciurus hudsonicus*. Canadian Field-Naturalist 119(2): 000-000.

On 2 November 2003, a freshly killed Short-tailed Shrew found beneath a bird feeder was likely the victim of an aggressive locally-resident Red Squirrel. The minimal amount of snow cover at the time is hypothesized to have prevented an escape such as had been observed in an encounter between these species in a previous year.

Key Words: Short-tailed Shrew, *Blarina brevicauda*, Red Squirrel, *Tamiasciurus hudsonicus*, aggression, Manitoba.

In mid-afternoon on 2 November 2003, I found a freshly-killed Short-tailed Shrew, *Blarina brevicauda*, lying on the seed-strewn ground beneath one of our bird feeders which is fastened to the trunk of a large oak tree. I could hardly have failed to notice the shrew had it been there earlier as the site is readily visible from out living-room windows. The shrew was lying on bare grass which two days earlier I had shovelled clear of a thin layer of new snow. Up to this time, I had not noticed any shrew sign. The dead shrew, a surprisingly thin female, had fresh bloody bite marks on the back of its neck, on one shoulder, and on the side of its head.

As I could think of no other explanation, I presumed that the shrew, which was possibly attracted by the bird seed, had been attacked and killed not long before I returned home from a short outing, as it was still bleeding. I guessed that the killer was one of our two resident Red Squirrels. One, in particular, an aggressive creature that established residence here in the previous spring, claimed this oak tree as one of its primary sites, regularly driving away other Red Squirrels and Grey Squirrels (*Sciurus carolinensis*); it also frequently harassed birds of nearly all species. Nevertheless, partly because we have two other nearby bird-feeding sites, songbirds do regularly visit here.

Previous observations of a Red Squirrel (not this particular one) showing similar belligerence have been of some interest. In this same general area, Nero (1996) noted that in early December 1995 a Red Squirrel was observed attacking a Short-tailed Shrew. That shrew struggled fiercely and then escaped its attacker by diving into a burrow in the snow. In the 2003 incident, owing to the minimal amount of snow in the vicinity, the shrew had no escape route.

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Received 18 December 2004
Accepted 17 April 2005

Extension de l'aire de distribution de la Couleuvre à collier, *Diadophis punctatus edwardsii*, dans l'est du Québec

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Deux Couleuvres à collier adulte (Diadophis punctatus edwardsii) ont été trouvées au parc national du Saguenay, dans l'est du Québec, en 2004 et 2005. Ces mentions se retrouvent à près 150 kilomètres au nord-nord-est de la mention la plus proche de l'espèce. L'habitat est constitué de forêt mixte près d'escarpements rocheux, dans des vallées. Il pourrait s'agir de populations isolées de celles retrouvées plus au sud.

Two Ringneck Snakes (*Diadophis punctatus edwardsii*) was found in the Saguenay National Park, in eastern Québec, in 2004 and 2005. These records are about 150 kilometers north-north-east from the nearest previous record. The habitat is mixed forest, with rocky cliffs, in valleys. They may represent isolated populations from those found in southern Quebec.

Mots-Clés: Couleuvre à collier, *Diadophis punctatus edwardsii*, aire de distribution, population isolée, habitat, Québec.

La Couleuvre à collier (*Diadophis punctatus edwardsii*) est une espèce discrète qui a historiquement été peu rapportée au Québec. Jusqu'en 1990 elle y était la couleuvre la moins souvent observée, les mentions de l'espèce étant confinées au sud de la province (Bider et Matte 1991). Il s'agit d'une espèce discrète et aux mœurs fouisseuses, qui estive durant les périodes chaudes et sèches (Ernst et Ernst 2003). Bien que difficile à apercevoir, l'espèce peut être abondante par endroits (Cook 1984; Ernst et Ernst 2003) et pourrait être plus répandue qu'on le croit (Desroches et Rodrigue 2004). Au Québec, la mention de Couleuvre à collier la plus à l'est, sur la côte nord du fleuve Saint-Laurent, a été faite à Saint-Joachim près du Cap-Tourmente (Provancher 1874), à quelques 40 kilomètres au nord-est de la ville de Québec.

Le 22 juillet 2004, un spécimen adulte a été découvert dans le parc national du Saguenay, municipalité de Rivière-Éternité, canton de Hébert (48°17'35"N; 70°20'38"). Sa longueur totale est d'environ 27,5 cm. Il porte sous le ventre une série de points noirs, au centre de plusieurs des écailles ventrales. La couleuvre a été trouvée morte en bordure d'un sentier, et son état laissait présager qu'une faucheuse l'avait découpée en morceaux lors de travaux d'entretien. Le spécimen est conservé dans la collection herpétologique du Musée canadien de la nature (CMNAR-35820). L'habitat est une forêt mixte dans une vallée encaissée, où poussent le Sapin baumier (*Abies balsamea*), le Bouleau jaune (*Betula alleghaniensis*), l'Érable à sucre (*Acer saccharum*), le Frêne noir (*Fraxinus nigra*) et des épinettes (*Picea* sp.). La strate arbustive se compose, outre les jeunes arbres des espèces cités précédemment, de l'Érable à épis (*Acer spicatum*), de l'If du Canada (*Taxus canadensis*) et du Noisetier à long bec (*Corylus cornuta*).

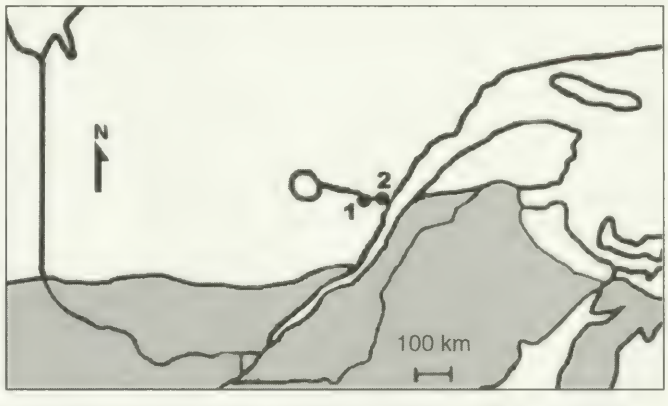

FIGURE 1. Répartition de la Couleuvre à collier au Québec et sur le territoire adjacent. Les mentions faites au parc du Saguenay sont répresentées par les points noirs numérotés (1 = Rivière-Éternité; 2 = Sacré-Cœur). (carte modifiée d'après Cook 1984; Bider et Matte 1994; Desroches et Rodrigue 2004).

Le 27 août 2005, un second spécimen de Couleuvre à collier adulte a été découvert dans le parc du Saguenay, municipalité de Sacré-Cœur, canton d'Albert (48°15'53"N; 69°56'49"O). D'une longueur totale d'environ 34,0 cm, il ne porte aucun point noir au centre des écailles ventrales. Comme ce fut le case en 2004, cette couleuvre était morte lors de sa découverte. Elle gisait sur une route d'asphalte, probablement écrasée par une automobile. Le spécimen a été récolté et déposé au Musée canadien de la nature (CMNAR-35821). L'habitat à cet endroit est une forêt mixte, où l'on retrouve l'Épinette noire (*Picea mariana*), le Sapin baumier, des peupliers (*Populus* sp.), le Bouleau blanc (*Betula papyrifera*), le Pin rouge (*Pinus resinosa*) et le Pin gris (*Pinus banksiana*). Beaucoup d'épines de conifères jonchent le sol.

Ces deux mentions de Couleuvres à collier se retrouvent respectivement à 140 kilomètres et 148 kilomètres au nord-nord-est de la mention connue la plus proche de l'expèce (Saint-Joachim (Provancher 1874)) (figure 1). Elles ont été faites de part et d'autre de la rivière Saguenay, soit à l'ouest (Rivière-Éternité) et à l'est (Sacré-Cœur) et sont séparées entre elles de 30 kilomètres. En effet, la répartition de la Couleuvre à collier, dans le sud du Québec, est associée aux différents domaines de l'érablière et à celui de la sapinière à Bouleau jaune. La saison de croissance y dure de 160 à 190 jours (Robitaille et Saucier 1998). La présente mentions faites dans le parc national du Saguenay, se situe dans le domaine de la sapinière à Bouleau jaune, et la saison de croissance dure de 140 à 170 jours (Robitaille et Saucier 1998). L'Érable à sucre, et dans une moindre mesure le Bouleau jaune et le Frêne noir, poussent dans le sud du Québec et de manière isolée au Saguenay (voir les cartes présentées dans Farrar 1996). La répartition de la Couleuvre à collier pourrait être semblable.

Le territoire séparant le Saguenay de la région de Québec (mention de Provancher 1874) est très différent. Il est constitué de hautes collines et de monts, et fait partie de la zone des sapinières à Bouleau blanc, à Épinette blanche (*Picea glauca*), à Épinette noire et de la pessière à mousse. La saison de croissance dure de 130 à 160 jours (Robitaille et Saucier 1998). Ce territoire semble peu propice à l'établissement de la Couleuvre à collier. Nos recherches effectuées dans ce secteur ne nous ont permis d'y recenser que la Couleuvre rayée (*Thamnophis sirtalis*), laquelle se retrouve au Québec presque jusqu'à la latitude 54° nord (MacCulloch et Bider 1975; Bider et Matte 1994; J.-F. Desroches, données non publiées).

La présence de la Couleuvre à collier au Saguenay est très intéressante; il s'agit d'une extension d'aire importante vers le nord-est pour l'espèce, et possiblement d'une population isolée. Les populations isolées de certains reptiles revêtent une importance particulière en conservation (voir dans Seburn et Seburn 2000). Tout comme Bleakney (1958) l'avait proposé, il est possible que le climat plus clément retrouvé dans la vallée de la rivière Saguenay favorise certaines espèces de l'herpétofaune qui sont absentes du territoire environnant, lequel est plus élevé en altitude.

Il se pourrait également que la répartition de la Couleuvre à collier soit plus continue et suive une mince bande le long de la côte nord du fleuve Saint-Laurent, entre la région de Québec et le Saguenay, comme pour les espèces d'arbres nommées précédemment (Farrar 1996) et conformément à la limite de la zone herpétofaunique # 4 proposée par Bleakney (1958, page 74). Des recherches supplémentaires sont nécessaires afin de préciser la distribution de cette couleuvre au Québec, particulièrement dans le nord et l'est, notamment aux endroits isolés où les conditions sont favorables à l'espèce.

Remerciements

Les auteurs remercient Rémi Bouchard pour la découverte du spécimen, de même que Francis R. Cook, Daniel Pouliot, Benoît Couture, Hugo Royer (parc national du Saguenay) et Isabelle Picard pour leurs commentaires sur la version préliminaire du texte.

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Received 27 October 2004
Accepted 24 August 2005
Revised 4 October 2005

Do Juvenile Nearctic River Otters (*Lontra canadensis*) Contribute to Fall Scent Marking?

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Olson, Zach H., Sadie S. Stevens, and Thomas L. Serfass. 2005. Do juvenile Nearctic river otters (*Lontra canadensis*) contribute to fall scent marking? The Canadian Field-Naturalist 119(3): 457-459.

We present photographic evidence in support of the hypothesis that juvenile Nearctic River Otters (*Lontra canadensis*) contribute to the observed fall peak in scent marking.

Key Words: *Lontra canadensis*, Nearctic River Otter, scent marking, seasonal variation, Pennsylvania.

Otters scent mark by defecating, urinating, or releasing anal glandular secretions at conspicuous shoreline locations called latrine sites (Melquist and Hornocker 1983; Swimley et. al 1998). Seasonal variation in scent marking intensity has been reported for Nearctic River Otters (*Lontra canadensis*) with peaks in spring (March-April) and fall (September-November) in Pennsylvania (Serfass 1994; Carpenter 2001; Mills 2004). There have been many proposed explanations for seasonally variable marking intensities in otters. Seasonal variation was associated with dominance and related to the dispersal of juveniles for a population of European Otters (*Lutra lutra*) in Wales (Macdonald and Mason 1987). Carpenter (2001) attributed the spring peak in Pennsylvania to mate attraction during the breeding season. Similarly, Mills (2004) believed increased spring marking was related to advertisement of location and breeding condition.

Home range studies provide evidence in support of breeding advertisement and breeding-range defense as causes for a spring peak in scent marking (Melquist and Hornocker 1983; Reid et al. 1994; Spinola 2003). Spinola (2003) reported a spring increase in home range and interactions with females by male River Otters in a reintroduced population in western New York. He invoked two hypotheses to explain River Otter spacing patterns: Sandell's hypothesis (Sandell 1989) and the resource dispersion hypothesis (Mac-

FIGURE 1. Photograph from the Youghiogheny River (Maryland) latrine site of two juvenile River Otters with one adult. The two juveniles are indicated with arrows. The juvenile in the foreground (trailing) appears large in comparison to the other River Otters because of its close proximity to the camera. The image is dated 30 June 2004.

donald 1983; Carr and Macdonald 1986), both of which predict female intra-sexual territoriality and large male home ranges during the breeding season (Spinola 2003). Increased scent marking during this period of increased movement would likely enhance the efficiency by which males and females are able to locate one another for breeding opportunities.

Although the possible link between spring breeding advertisement and the observed spring peak in scent marking has been established, there is a paucity of literature examining causes of the fall peak in scent marking. Carpenter (2001) and Mills (2004) suggested the mechanism for a fall peak in North America was an increase in the density of marking individuals as juvenile River Otters began traveling with their mothers (juveniles were <1 year old). However, we are aware of no data that support this hypothesis.

As part of an ongoing behavioral study of River Otters we placed remote, 35-mm cameras (TrailMaster®, Goodson and Associates, Inc., Lenexa, Kansas, USA) at latrine sites along Tionesta Creek in north central Pennsylvania (41°35'N, 78°15'W) and the Youghiogheny River in western Maryland (39°34'N, 79°25'W), United States. Two cameras captured what we presume to be two family groups (an adult female and two cubs as defined by Melquist and Hornocker 1983) of River Otters visiting latrine sites beginning 30 June 2004. We based this presumption on a size disparity apparent among individuals in three photographs containing all family group members. The photographs originated from two separate latrine sites, one from a Tionesta Creek latrine site (15 August 2004) and two from a Youghiogheny River latrine site (30 June 2004 and 31 July 2004). We continued to obtain photographs at those latrine sites ($n = 2$ at Tionesta Creek and $n = 10$ at the Youghiogheny River) of what we assumed to be the same family groups through fall and winter 2004.

To estimate the lengths of the presumed juvenile and adult River Otters we took reference photographs of both latrine sites. The reference images were taken from the same camera mount and position as the original photographs and incorporated meter sticks placed at the locations of the River Otters in the original photographs. We digitally superimposed each reference image onto the original image containing the presumed family group of River Otters, thus facilitating an approximation of each individual's total length (tip of nose to tip of tail). The 30 June 2004 photograph from the Youghiogheny River was not subjected to these measurements because the size disparity was readily apparent (see Figure 1). In both of the other photographs two presumed juveniles were visible, but only one was captured completely within the photograph frame and could be measured. The presumed adult and juvenile at Tionesta Creek were 78.2 cm and 61.4 cm, respectively, which yielded an adult length to juvenile length ratio of 1:0.79. At the Youghiogheny River, the presumed adult was 86.2 cm and the presumed juvenile was 63.8 cm, which yielded a ratio of 1:0.74. The shorter calculated lengths than those expected from physical measurements of the same River Otters was probably due to the animated posture of the photographed individuals.

Our calculated ratios are consistent with the findings of Stephenson (1977), who reported November-March trapped <1 year-old River Otters in Ontario of significantly lower weight and length than all other age classes. Merriam (1884) reported observations of young otters with their mother in summer and fall in the northeastern United States. Also, Park (1971) listed fall as the season juveniles began traveling with their mothers. We propose that our photographs were of River Otter family groups, juveniles visiting latrine sites with an adult, and that the increased number of River Otters at latrine sites can explain an increase in the number of scats at latrine sites.

Liers (1951) and Melquist and Hornocker (1983) have described River Otter scent marking as a sort of positive feedback loop — one otter's scent marking induced other nearby individuals to mark, which induced another round of marking by the first otter, and so on. This type of release stimuli — possibly visual and olfactory — has been described for other scent-marking carnivores (see Beckoff 1979; Muckenhirn and Eisenberg 1972; Peters and Mech 1975; Seidensticker et al. 1973). Family groups of River Otters visiting latrine sites would, therefore, leave more scats than single otters. Although release stimuli could explain increased scat numbers at latrine sites in the fall, the function of scent marking as a group has not been addressed for River Otters. Ewer (1973) proposed that group scent marking in social carnivores could facilitate group bonding (page 250). The social significance of scent marking has been described in canids (Rothman and Mech 1979), felids (Seidensticker et al. 1973), and other mustelids (Buesching et al. 2003).

Although more information is needed before making final conclusions, we believe evidence from the literature that a family group begins to travel as a unit during summer, and our observation of juveniles accompanying an adult to latrine sites beginning in late June, lends support to the hypothesis that juvenile River Otters contribute to increased scent marking in fall. Specific aspects of River Otter scent marking at latrine sites that have not been addressed in the literature include; the composition of marking individuals, the periodicity of marking by individuals, and the relationship between functional scent marking and elimination of feces.

Acknowledgments

A United States Fish and Wildlife Service State Wildlife Grant (administered by the Pennsylvania Game Commission [PGC]), the Pennsylvania Wild Resource Conservation Fund (WRCF; nongame tax-checkoff), and the United States Department of Agriculture Allegheny National Forest (ANF) provided primary funding and support for this project. We are

grateful to A. Hayden (deceased) and J. Hassinger of the PGC, F. Felbaum and R. Stanley of the WRCF, and B. Nelson of the ANF for their cooperation and support of River Otter research in Pennsylvania.

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Received 15 March 2005
Accepted 7 July 2005

Book Reviews

Zoology

Damselflies of Alberta: Flying Neon Toothpicks in the Grass

By John Acorn. 2005. University of Alberta Press, Ring House 2, Edmonton, Alberta T6G 2E1 Canada. 156 pages. Can $29.95.

I have a very strong interest in entomology, but no particular interest in Odonates, save for collecting the odd one for my odonatologist colleague. This small book has served to enlighten me and further my interest; I will look at damselflies more closely now.

In the bulk of the Preface, Acorn waxes about the restraints of scientific writing and laments about how dull it is to him. He prefers to write "in a frank and personal fashion, admitting to one's influences, desires, uncertainties and dislikes." However, much of "his" style (frank, admitting to influences and uncertainties) is the basis of scientific writing as well. Literature must be directed to an audience, and I don't think an odonatologist would find "dull" the scientific writing directed to his or her guild. A quick look at the bibliography reveals that the vast majority of works consulted for Acorn's book is from the scientific literature.

Having read the book, and having seen episodes of Acorn's TV show and his video interpretations at the Tyrell Museum, I believe Acorn is a wonderful author for children (e.g. "A big, mean, scary female water spider" is part of one caption in this damselfly book), but I don't think that writing for children alone is the intended extent of his scope. Acorn's goal is to write for the general public and to get people interested in natural history, and this book helps in that. However, the author does not give credit to people's intelligence…he changes names of structures on the damselflies simply because they sound too much like jargon to him. I'm at a personal crossroads on this point – I firmly applaud Acorn's message of natural history education for everyone, but to me, his writing style actually detracts from getting the most out of the information in the book. For example, I did not find the limericks at the beginning of each species description at all interesting, humorous or otherwise worth the space. I believe one must write appropriately for the intended audience; there is no such thing as a book for all ages. And I do not enjoy reading books that seem to be written for children.

Technically, the book has very good points, as well as a few unfortunate oversights. The book is of a convenient size, suitable for taking in the field. The photography, while not stunningly appealing, is still quite vivid. It is not clear why there is a photograph of a dragonfly nymph in the introductory chapter, and none of a damselfly nymph; the latter ultimately does appear later in the book. Acorn describes the *necessity* of using a 10× lens to be able to identify damselflies in the field, yet there are no photographs of *any* of the features at this magnification in the book (there are some useful line drawings at the back of the book). However, this small book *is* packed with a lot of useful information on identification, ecology and behaviour of Alberta's damselflies, and for that reason alone would make a worthwhile addition to a naturalist's library.

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Botany

Flower Guide for Holiday Weekends

By E. Larsen and B. Roots. 2005. National Research Council Canada, 1200 Montreal Road, Ottawa, Ontario K1A 0R6 Canada. vii + 149 pages. Paper.

This book is arranged to cover three key holiday weekends. The choice of weekends works equally well for both United States and Canada [Victoria Day/Memorial Day, Canada Day/Independence Day, Civic Holiday/Labour Day]. This is a good concept that will be most helpful to novices and visitors. By choosing your date you can readily see which of the common, showy flowers are in bloom and thus narrow your search for the identity of a flower.

Each species is covered by a good strong narrative in layman's terms. While this text is non-scientific it is enlightening and helpful. This is accompanied by one to four photos of the plant, its flowers, seed, etc. The photos are top quality and are artistically set in the book, adding to its charm. The edges of the pages are coloured yellow, orange or blue to make it easy to pick the weekend. The book is relatively small so will slip easily into a pack or pocket.

Although 64 flower species are covered, eight of these are repetitions. That is, the text and photos are virtually identical. I do not see the point of this. A list of plants with overlapping flowering times would have been sufficient. In the extra space the authors could have added some new plants.

This book would make a delightful gift for a traveller, cottage owner or those who simply like a good walk.

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Orchids of Manitoba

By D. Ames, P. B. Acheson, L. Heshka, B. Joyce, J. Newfeld, R. Reeves, E. Reimer, and I. Ward. 2005. Native Orchid Conservation Inc., 117 Morier Avenue, Winnipeg, Manitoba Canada. $17.95 + shipping charges.

This 158-page book with soft covers includes 36 orchid species known to occur in the province of Manitoba. It contains 218 absolutely beautiful colour pictures of different aspects of these delightful orchid plants in the text plus two more on the front and back covers.

The text begins with acknowledgements to all the individuals who have provided suggestions towards the book's production, the Manitoba Conservation staff for their guidance and the use of their maps, Kromar Printing for their assistance and getter the colours just right, and the financial support provided by the Province of Manitoba Special Conservation Fund, Shell Environmental Fund, and The Winnipeg Foundation. It is also noted here that the Native Orchid Conservation Inc., the publisher of this book, is a non-profit organization formed in 1998 to protect unique mini-ecosystems and their plant communities. This is followed by "A Brief History of Orchids," "Conservation and Biology," "Protection of Species and Ecosystems", "Orchid Biology", "Orchid Habitat" (including a map of Ecozones of Manitoba and sixteen pictures of habitats), a "Key to the Orchids of Manitoba" (when in flower), and an "Introduction to the Species Accounts." The latter provides information on scientific names, abundance, habitat, flowering time, description, aids to identification and range maps.

Pages 45 to 145 are devoted to the illustrations, the distribution maps, and the most interesting descriptive text for the 36 orchid species treated in this book. Each descriptive page provides information on the common and scientific names, abundance, habitat, flowering time, descriptive information, aids to identification, and additional comments. The flowering times for Manitoba orchids are presented in alphabetical order of the scientific names with the common names in brackets on pages 146 to 148. This is followed by a bibliography on pages 149 to 151 and a Glossary on pages 152 to 155 and an Index on pages 156 to 157 which contains scientific names, common names and selective descriptive names to help the readers. In addition, a "Foreword" was provided by Paul M. Catling.

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ENVIRONMENT

Environmentalism Unbound: Exploring New Pathways for Change

By Robert Gottlieb. 2005. MIT Press, Cambridge, Massachusetts, USA. 2001. 287 pages. US$74.25 Cloth, $20.83 Paper.

Robert Gottlieb is professor of Urban and Environmental Policy at Occidental College in California, and his study area involves a variety of environmental policies and practices, mostly in the Los Angeles area. In our modern world, where diversity is publicized as the omen of political correctness, but where the survival of the richest is often the motivating factor, environmental awareness is reduced to single questions which can be handled by one-issue political campaigns. Single issues may facilitate winnable environmental battles but the strategy can leave other important areas without advocates. Gottlieb places the environment into the context of the whole sphere of life and shows connected parts interacting to create our quality of lifestyle. Unfortunately, as an urban environmentalist, his examples more often show how each of the parts has been contaminated by different political and commercial interests and the big picture purposely left as a large unexamined grey area. This book is an attempt to reconcile many interests and show inroads which have already been made and can reasonably expect to be made in a number of industries by response to human needs, well-planned activism and some creative thinking.

The focus of the book is urban environmentalism exclusively in the United States, but as a study of that country, it informs us of the actions of environmental groups, the battles they fight and the progress they have been making. The ideas presented are ones which were studied in Los Angeles but the implications for change are important for the rest of North America. Is there an alternative in the dry cleaning industry to the solvent perchloroethylene? Can fresh fruits and vegetables be locally grown and marketed outside of multinational grocery and food distribution companies? And can the cleaning industry perform their service

with environmentally-friendly chemicals, just wages, and competition which allows independent operators to remain active?

In answering these questions the book includes a lot of data presented in a readable narrative telling how the system of business and human resources relates to the environment, and how the agents of change have to be real agents in people's lives and business interests. In our society respect of the environment also has to take into account our financial securities and business success or failure. Gottlieb gives us details of different cultures, situations, and businesses impacting on environmental justice and pollution prevention situations.

The book is divided into two parts. The first part is a discussion on the bounds and restrictions which people feel when confronted with issues of environmental justice. Corporate excuses, small companies' pressures to survive and individual citizens' concerns for cleaner, healthier living are all parts of the discussion. All of these human situations impose boundaries on action proposed by environmental concerns or pollution prevention schemes. Gottlieb shows us good news too, where some positive steps have been taken in urban areas and where work is in progress.

The second part tells stories of three industries which are embracing change under the conditions discussed in the first chapters, the dry cleaning industry, the janitorial cleaning suppliers and the community's supply of fresh, economical and local food. Gottlieb takes us into a history of the dry cleaning industry, its beginnings, growth, present status and the future of the industry. There has always been potential for pollution in that industry and our desire for hygiene has constantly been at odds with the very mechanics of maintaining the service which we have adopted. On the horizon for us, there are potentials for a cleaner service with less pollution, and the alternative of more efficient ways of using the same service but with the same kind of pollution.

The providers of office cleaning service have an industry which is rampant with low-salaried workers using volatile chemicals with little or no training nor protection from fumes, skin contact or emergency response. Smaller operators are forced to compete or go under and use the same chemicals also without training. Illegal aliens, underage and family workers are all involved to make a small business operate successfully. And when the family and the underpaid workers spend their wages, they often have to shop in neighbourhoods which are under-served by the large grocery chains because their urban area is too poor to support a store which will guarantee a supply of fresh nourishing fruits and vegetables so readily available to the more affluent areas. Local urban bylaws will also keep open-air markets from operating in poor neighbourhoods, and local growers and suppliers would not be able to market independently due to health by-laws or zoning bylaws heavily influenced by the same chain superstores which will not locate in the poor neighbourhoods.

The book has a wealth of information from careful scholarship and even has some good news for the future. As most of the environmental literature, it shows the amount of work which is going on and the lack of or limited successes which environmental policies can gain. Much more work remains to be done, but the story is being told and Gottlieb tells the story well holding our interest in each part.

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The Love of Nature and the End of the World: The Unspoken Dimensions of Environmental Concern

By Shierry Weber Nicholsen. MIT Press, Cambridge, Massachusetts, USA. 2002. 199 pages. U.S.$67.50 Cloth, $18.90 Paper.

Nicholsen attempts to bring together the thoughts and philosophies of great nature writers, teachers and thinkers as well as thoughts and writings of artists and psychologists to make her points in this work of nature study and doomsday warning. The book wants us to consider our place in the development of the world, to consider and reconsider the place of people within the natural world unfolding, and our presence so strongly felt in each part of the world. Human presence is an essential part of the world rather than opposition to the world, and nature does not need to be suppressed in order for us to have a fullness of life. But nature has to be meaningful to us first, since our capacity to appreciate the world around us impacts upon our own interior life and perception of what will sustain our lives. If we cannot see the world around us, we cannot care for it.

The text reads as much like a poem as a discussion in many places, with quotes from a great variety of writers illuminating the points which Nicholsen tries to make. I found myself leafing through the book to reread quotes from Thoreau, Paul Shepherd, Gary Snyder, Aldo Leopold and Jack Turner. Many other writers from a variety of traditions are included illustrating the views of nature synonymous with art, spirituality, philosophy and psychology. In fact, the Name Index lists 135 different authors, some of them quoted several times, a large number of source authors for a 200-page text. The number of authors included shows us the magnitude of literature supporting Nicholsen's thesis; love of nature is one of the defining aspects of art, spirituality and philosophical thinking over the ages.

We are faced with a crisis but we have responded with apathy, and unconsciously decided not to react to the crisis at all. At the same time, everyone we meet is has some concern and appreciation for at least part of the environment. How does this split in our thinking persist? Our society has grown so used to taking the world for granted that we can neither be shocked nor shamed into doing anything about the ecological crisis because we are inundated with other more shocking news every day and we have made the decision that we will continue to exist without paying attention to the evidence before our eyes. This decision, expressed by psychologist Harold Searles, gave Nicholsen the idea for the book. Our decision, Nicholsen wants us to know, is wrong and a denial of the evidence we can see as well as denying North American Native wisdom, Christianity, Islam, and Buddhism among other teachings of the ages. Artists, philosophers, and teachers of nature all give evidence of what we are missing, and what we are destroying, but we do not respond because we have already made up our minds not to take the wisdom into account.

The book recognizes that our relationship with our world is destructive and has always been so, from the moment when we began to kill wildlife and uproot plants to nourish ourselves. However, killing and uprooting are only the beginning and not the end of our relationship with our world as we know, but could well become the fulfilment and fate of the world if we cannot see beyond incidentals. This book is an opportunity to see beyond where we are, which direction we seem to be going and an invitation to visit the wisdom of the ages. The sages teach us that the progress of nature does not despair of the possibilities of the future and neither should we. Nicholsen shows us a bleak path of destruction, but with the thread of hope that nature itself interpreted by writers past and present can lead us back to a positive relationship with the world in which we live.

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Survival by Hunting: Prehistoric Human Predators and Animal Prey

By G. Frison. 2004. University of California Press, Berkeley. xix + 266 pages. Can $47.25 Cloth.

The archaeological excavations in which I have been involved in interior western Canada often yield large amounts of animal bone, eloquent testimony to the importance of hunting for people in the past. Like most modern urban people, however, I have never hunted or butchered animals and so my ability to understand what I see in the archaeological record lacks this source of enrichment. In his fine book, *Survival by Hunting*, George Frison argues that direct hunting experience is a fundamental source of knowledge for archaeologists and laments the fact that most know nothing of this activity. He expresses his "dissatisfaction with ethnographic and archaeological interpretations of human hunters and hunting that fail to acknowledge the years of experience and the accumulation of knowledge of animal behaviour required to become a successful hunter." In Chapter 9 ("Concluding Thoughts"), he reiterates his frustration "that human hunting has wrongly been viewed as a kind of instinctive behaviour not worthy of serious anthropological study." On the contrary, he states that "'killing an animal' hardly describes the body of learned behaviour acquired over a long period of time that leads to that final act." He argues persuasively for an experiential approach to archaeology, using his own life and career as exemplars. As such, this book contains a great deal of information about animal behaviour and biology, though viewed from the perspective of a hunter.

Although he does not express it in quite these terms, my reading of Frison's argument suggests that he is impatient with the attitude of students who regard hunting and killing an animal as easy, whereas they regard the butchering and use of the remains as the difficult part requiring interpretation. Perhaps this is because the process of hunting, as opposed to the kill and carcass use, leaves scant archaeological remains. Certainly, there are sites, such as Head-Smashed-In Buffalo Jump in southwest Alberta, where drive lanes and terrain configuration allow some reconstruction of the hunting strategy. But in most cases, especially where sites are deeply buried, this level of information cannot be recovered. The hunting process, as Frison describes it, involves an intimate knowledge of animal behaviour with a sophisticated understanding of terrain, and demands adaptability, persistence, and considerable strength and physical skill. Much of this, therefore, resides in the mind of the hunter and not in the material culture or discarded faunal remnants found at an archaeological site.

The first two chapters ("Where the Buffalo Once Roamed" and "The Education of a Hunter") draw largely on Frison's own life experience. He describes how he grew up in northern Wyoming in the 1920s and 1930s, learning to ride and hunt with his grandfather, partly to undertake predator control, and partly to supplement the food supply on the ranch. He spent much of his early adult life as an outfitter and guide. He recounts how his interest in archaeology grew from his encounters with sites and artifacts while he was out on the land. His fascination with this material and the people of the past who made it increased, until finally, in the 1960s, he was persuaded to enter the academic world, gaining formal training in the field that absorbed him. In the decades since then, he has excavated and published accounts of many of the most widely-known archaeological sites in the interior northwestern United States. These include the Casper site, Agate basin site, Horner site, and Mill Iron site. Perhaps because he was an outdoorsman first and an archaeologist second, his work has always included, perhaps to a greater ex-

tent than many other contemporary archaeologists, an appreciation for the subtleties of the terrain around the sites.

The heart of the book concentrates on the hunting of the large mammals that were major food sources for people through the past eleven millennia. The regional focus is the interior of North America, mainly the northern Great Plains and adjacent Rockies of the United States, the areas where Frison has spent most of his life and career. Frison begins his survey by considering Paleoindian, notably Clovis, hunters and the approaches they might have taken to hunting the now extinct megafauna, especially mammoths, around 11 500 to 10 000 years ago. This chapter is more speculative than the rest and, because there are no mammoths around to hunt today, it is obviously less based in personal experience. Elephants, perhaps, are the nearest one can now get to mammoths, though it is unclear how closely their behaviour and reactions to hunting are analogous. Frison describes some butchering experiments undertaken during elephant culls in Zimbabwe. From his account, cutting up an elephant with a stone knife is a lengthy, messy, and tiring process!

The next three chapters each focus on one of the "big three" prey mammals of the northern plains and Rockies: Bison, Pronghorn, and Mountain or Big Horn Sheep. As merits its importance in the archaeological record, the bulk of this discussion (almost 60 pages) focusses on Bison. This chapter begins with a consideration of the palaeontological evidence for different Bison species – a subject about which there is still much debate – followed by a survey of selected archaeological Bison kill sites. Frison reviews the several strategies that were used to hunt and kill Bison, resulting in kill sites of different types including arroyo traps, Bison jumps, and corrals. He then presents some interesting observations of Bison behaviour based on Bison ranching, knowledge that is needed in order to judge how the animals might react to various situations. One point that comes through strongly from these accounts is that cattle are not a good analogue for Bison because their behaviour and biology are quite different. Frison structures sections on Pronghorn and Big Horn Sheep in the same way, with an introduction to the animals' biology, ecology, and behaviour, emphasizing traits, such as herding, that would affect hunting strategies. He summarizes ethnographic accounts of hunting and then describes the archaeological signatures of procurement. These are often different and characteristic for each animal: corrals for Pronghorn and small traps or pens made of logs for Big Horn Sheep in the high country.

Chapter 7 deals with the hunting of various other animals in the same region. These include large animals – specifically deer, both White-tailed and Mule deer, Elk, and Black and Grizzly bear – and small mammals, especially rodents, and birds. Although sometimes present, these tend not to feature as prominently in the faunal assemblages from archaeological sites in the regions under consideration. Indeed, Frison questions whether "small mammal procurement should be considered in the category of 'hunting'". Nevertheless, birds and small mammals may have been important diet items in some circumstances, although perhaps not as "archaeologically visible" as large mammals. The discussion of birds is quite brief and deals with only two (Sage Grouse and Blue Grouse); I found it interesting that there was no discussion of waterfowl hunting. Frison comments (page 178) that he has no experience with hunting Caribou, another large mammal that was an important food source for people further north. Frison briefly describes an unusual arrangement of canid faunal remains. Although this seems one implication, he does not discuss potential ceremonial aspects to this arrangement, while he does mention possible ceremonial aspects to arrangements of Elk antlers and Big Horn Sheep horns. However, throughout this book, Frison's focus is on hunting animals for food; other possible reasons for animal procurement are only touched on tangentially.

Throughout these chapters, Frison has mentioned the various weapons that were used in hunting. Chapter 8 brings this together and concentrates more explicitly on "Weaponry and Tools Used by the Hunter". The main weapons include the spear, the bow and arrow, and the atlatl. Stone tools include those used to butcher and process an animal, such as knives, hammers, and scrapers. With respect to these weapons and tools, our perceptions may be strongly coloured by what is recovered at archaeological sites, that is, mainly artifacts made of stone, although Frison does include some discussion of weapons and tools made from other materials, such as bone, antler and ivory. There is a further bias in the archaeological record because only part of the weapon system, the projectile point, is usually recovered. The other essential parts of the technology, such as wooden spear shafts, sinew lashings, bow strings, etc., which are made from more perishable materials, are rarely preserved in this region, except in unusual settings such as dry caves.

This is a truly fascinating book. It is a "must read" for professionals involved in archaeology, and plains archaeology especially. But anyone with an interest in the lifeways of people in North America prior to European settlement will find much to ponder on here. For naturalists, the main interest of the book lies in the practical observations on behaviour of some major large mammals of the continental interior. A career statement from one of the towering figures in late 20th century North American archaeology, this volume represents the distillation of a lifetime's experience garnered by fieldwork and reflection.

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Wildlife, Conservation, and Human Welfare: A United States and Canadian Perspective

By R. Taber and N. Payne. 2003. Krieger Publishing Company, Malabar, Florida. US$29.50 Cloth.

This book is a firework; it is full of incredible details on managed and mismanaged wildlife and natural resources. The beauty is that this convincing text comes from two acknowledged experts who are actually within the wildlife management circles, and who have worked in this discipline for over 30 years. Therefore, one can hardly find a more honest and matching description of the current state of wildlife management in North America, and elsewhere. It will hopefully put publications by B. Lomborg (*The Skeptical Environmentalist*) and others to rest, and lighten up the entrenched old-fashioned sections of the wildlife community towards new horizons. The authors state that "...the traditional resource coteries tends to resist change. It has a high level of internal coherence and devotion to a well-defined philosophy, and is led by individuals educated in an earlier age".

This fascinating book offers 14 chapters showing shockingly how far away we still are from a truly sustainable wildlife management; e.g., as requested by the Rio Convention 1992, by common knowledge and by textbooks of science-based resource management. The Chapters 5 "European Trade" and 6 "Exploration and Settlement" expose our recent globalization as a simple repeat of history. I suggest Chapter 12 "Broadening Conservation and Wildlife" as required reading for any scholar of wildlife and natural resource administration.

The authors expose nicely that the widely heralded concept of "multiple use" often simply meant nothing else than: "Fiber first, and wildlife last". They provide extensive examples of how harmful unsustainable management of resources is: in part, Alaska was sold to United States from the Russians due to their overexploitation of fur and other resources (oil and gas wasn't known by then). The Roman Empire fell due to the failure of blending economy and society, including deforestation, overgrazing, erosion and pollution of the natural environment. Once the Roman dominance ended approximately 500 AC, it led into the Dark Ages lasting from 400-1400 AC; a so-called period of intellectual stagnation. Another example referred to in this book: in 1841 the Russians abandoned their southernmost port, Fort Ross, on the coast of northern California because the local supply of marine mammals (not only sea otters but also fur seals) was already exhausted by overhunting. It was only the gold findings in California in 1848 that brought a new group of settlers into the region.

During the 218 pages of fascinating text the authors destroy the Myth of Superabundance of wildlife in North America. The United States list of "vertebrates in jeopardy" consists of over 78 birds, 14 reptiles, 12 amphibians and 71 fishes, and of additional 148 invertebrates, and 596 plant species.

The book makes a strong case that the natural environment is a vital component of the human environment. It shows nicely that the developed nations have 22% of the world's human population, but use 88% of worlds' resources, 73% of its energy, and generate most of its waste and pollution. Whereas 78% of the world population consumes only 12% of earth resources. Instead of calling the Third World "less developed", the authors suggest to call them "less consumptive" (and consequently the western world "more consumptive"). The authors make clear that North Americans use the land and energy resources from the rest of the world: the average U.S. citizen consumes 50 times more than average citizens in India. Despite subsistence lifestyles in rural areas, it was the people of the urban activism, concerned with non-material rather than material satisfaction, that started "Earth Day" (actually led by U.S. Senator G. Nelson). It resulted eventually into the green or environmental movement and had a global impact.

Perhaps some readers would not expect such revolutionary and "challenge the hierarchy" thinking and statements from authors that are Vietnam veterans. But these successful Wildlife Managers with an emeritus status, one of them a former Aldo Leopold student, have gone environmental for a good reason: our current economy regime harms wildlife and habitats alike. The authors do a brilliant job in summarizing their own research work as well as the current wildlife habitat dilemma of the second millennium. For instance, one reads throughout the book that market incentives fail too often to conserve or use biodiversity on a sustainable level, "...they even facilitate degradation of ecosystems and depletion of species". One of the provided examples deals with the Hudson's Bay Company which, clearly held a monopoly, and did what monopolies do best: unconstrained exploitation until they overexploited the resource; buying low and selling high but without any considerations of long-term sustainability. History taught their business attitude a lesson.

The authors provide a brilliant analysis and description for furbearers, and how it affected the global community: already by 1840 Beavers became commercially extinct, almost world-wide! By then, silk replaced fur, and prices dropped for Beaver. In contrast to other fur animals such as fox, lynx, sable and ermine, Beavers are herbivores and thus they occur in high populations and are readily harvestable. The fur trade began approximately in 1500 in Cape Breton, Canada, delivering products to France and Spain/Portugal. Quickly, North American natives then became part of a global market economy; e.g., via Holland, England and France. Fur trade meant predominantly "beaver". Before the North American fur quest started, Europe, as well as parts of Russia, were already hunted out for Beaver pelts. The introduction of steel traps in 1750 and their mass production did the rest to harm populations of

Beavers and other furbearers. As authors show, Beavers in the New York region, the location of one of the first bases of the Hudson's Bay Company, were quickly eliminated. The nearby St. Lawrence and Great Lakes regions, down south to the Gulf of Mexico even, were next, and then followed by the boreal forest zones. Both sides of the Pacific Coast came last, which got enforced by the North West Company and Russian trade companies. Once the Beaver was "done", Muskrat and Raccoon were next in line.

This book is one of the best reads as a resource for wildlife management issues and related details: In North America, since the 16th century, 94 birds and 36 mammals became extinct, and 253 birds and 316 mammals are almost extinct. As the Hawaiian example shows, "Captain Cook opened the way to the extinction of 90% of the indigenous species of birds…and introduced species (870 plants, 2000 invertebrates, 80 vertebrates)". Within only 20 years of its discovery by the western world, Steller's Sea Cow became extinct; it took approximately 100 years for the Sea Otter. Asian Lions were found for thousands of years all over Asia, Africa and southern Europe; but in recent times they were reduced decade after decade and are now only found in India. As further shown, the experiences with Galapagos tortoise, Gray and Bowhead Whales are not any different. "Among the American colonies, local extirpation was the order of the day". It's simply part of the 'American way of life'; one of the largest export products ever existed. Settling the United States automatically meant extirpation for species such as Moose, Elk, Bison, White-tailed Deer, Wild Turkey and Beaver. "Wildlife populations in the more densely settled east were declining by 1850…". And "… as railroads connected markets a lively wildlife trade continued". Frontier farmers turned into commercial producers with railroad connections increasing pressures on the wildlife resource which resulted in further declines and extinction. Nowadays, the eastern American Black Duck population has declined due to acid rain.

This books brings interesting native issues to the forefront as well: refuges along native tribe borders always had enough deer and wildlife because they represented an "unused grey-zone". But their wildlife abundances crashed immediately once tribe borders changed. The quest by European's for furbearers brought human diseases into the land previously dominated by natives, an area over 5000 miles in diameter, and one of the worst cases of disease spread ever known in human history. Subsequently, that reduced native hunting pressure on wildlife; e.g., Bison populations sextupled! Nowadays, natives in Canada and elsewhere face two options: merge with dominant industrial culture, or adapt their traditional culture to new conditions.

The authors show that federal public lands are under direct control of the president of the United States via U.S. federal agencies [e.g. U.S. Fish and Wildlife Service (USFWS) and U.S. Bureau of Land Management (USBLM)]. However, only 3% of the United States is actually protected (whereas Costa Rica has over 12%). Further, "most private land in U.S., more over the half total, is managed on economic principles within short time frames and with no discernable concern for human welfare in other than monetary terms, or for ecological sustainability."

Very enlightening are also the presented views and constraints about the wildlife and management profession itself: "A manager in industry who does not please the stockholders can be replaced. A manager in a public agency who does not please the traditional agency clientele can be punished in several ways, among them transfer, reduction in budget, no promotion, or salary increase." But eventually, this person is still irreplaceable, blocking progress and contributing to the Cult of Incompetence which is nowadays widely seen in governmental agencies ("dead wood"). As shown in this book, such a situation does not only create frustration but supports environmental devastation on large scales.

Need an example? The authors provide plenty: "Biologists closest to the natural behavior of endangered species have encountered the natural behavior of government agencies and its negative consequences for species recovery. In a broader view, it seems that practically all human entities involved in an endangered species recovery program will benefit most, materially, as long as the species does not become extinct but never recovers to a viable population level". The direct effect from this entrenched but incredibly harmful management and governmental culture of wasteful nothingness is that 65 forms of mammals are in jeopardy (according to the USFWS list from 2002; 251 forms are in jeopardy in other countries); many more life forms are under consideration but this is way beyond capability of the agencies. Despite the governmental management and mandate, much wildlife is not adequately considered nor managed.

The authors emphasize "…the ancient continuing tendency towards Tribalism" and "testosterone" in the wildlife discipline: especially young men follow agencies and clubs, including their agendas such as provided by professors, coop units, USFWS and CWS. The authors quote: "… government programs at every level are the responsibility of a multitude of separate regulatory agencies, each with a primary interest in self-preservation and continued customary service to its traditional clientele, and steadily supplied with new recruits from specialized professional curricula at universities." And "…the cadres managing the various renewable natural resources had inevitably been becoming more and more inner-directed, i.e., out of touch with these new cultural changes. Each managerial group was recruited from students attracted to the appropriate professional curriculum, the student was indoctrinated with the traditional philosophy of that particular resource by instructors who had a similar education and had often served in the industry or agency dealing with that resource. Each renewable resource then had its adher-

ents: students, instructors, researchers, agencies, industries, and particular user-groups, supporting and served by sympathetic elected legislators. Such a cadre focused on a particular resource and became more and more internally coherent over time, producing accepted terms and philosophies of management, with members meeting one another periodically to re-enforce the mutual vision of how their resource should best be managed. Eventually, as the whole society developed new perspectives, these traditional professional resource groups began to lose public trust and esteem. Perceived as a threat to draw each resource cadre together in a defensive posture."

Despite all these great and important contributions, I find the book does not address really well the actual mechanisms of how wildlife links with humans; e.g., why only 7% of North American adults hunt. For over 100 000 years humans made 99% of their living through hunting, and at least ⅓ of their diet consisted of meat. Taber and Payne show cases where hunting contributed to extinction of large mammals, such as with the North American native tribes of the Cahokians and Hohokam; humans as r-strategists. For the American sportsman, the loss of prairie grouse (Sharptail, Greater Prairie Chicken, Lesser Prairie Chicken) got simply compensated by the introduction of alien species such as Ring-necked Pheasant and Gray Partridge. The authors state that many national leaders were former soldiers, and this can affect wildlife due to the hereditary soldier-rule and aristocrat views which got directly imposed onto the environment then, and onto its legal administration. This forms a huge and lasting culture, as can be seen to this very day in the German Prussian, French, Russian, Royal English and even African hunting codes shaping the current set-up of wildlife, habitats and resulting attitudes of the globe. The authors make a strong case that the Legal Hunting rights for the common citizens in England were gradually reduced to nothing.

The text sections for National and Protected Parks are a great and very informative read: "When wildlife in the colonies became threatened, generally by human population increase and pressure on wildlife habitat (as it had in western Europe in medieval times), colonial administrators set aside some of the best remaining habitats as wildlife sanctuaries (just as their ancestors had done in medieval times). Most of these were established in 1930, til break up of colonial powers in the 1950s. Cultural concepts of wildlife conservation came to Canada and the U.S. principally from England…". This approach was often encouraged by the upper class society; e.g., reflected in many wildlife funding schemes. In America, the first National Park came into existence in 1872 in Yellowstone (where hunting was still allowed for the subsequent 22 years), and in Canada in 1887 with the Rocky Mountains park (now Banff), whereas the first real reserve was founded as early as 1832 with the Arkansas hot springs. In 1881, the first U.S. forest reserves got established, followed 1906 by the Forest Reserves Act. This is the lasting effect when hiring leaders with vision (in this case G. Pinchot 1901).

However, the authors report that despite National Parks, many endangered species are found in habitats fully shared by humans and far from protected natural areas. "No reserve, no matter how large, is large enough to sustain a viable population of its more space-demanding species". The buffer zones are supposed to improve this situation but this is an area where humans encroach, too. Authors hint to the controversial point of view of a consumptive use of National Parks in the Third World.

I really like the great descriptions and summaries of legal events that put wildlife management in a policy context: By 1969 the U.S. just had experienced three decades of unparalleled prosperity when the U.S. National Environmental Policy Act (NEPA) was initiated with the U.S. National Council on Environmental Quality (NCEQ) overseeing this process. The intent of NEPA is to force agencies predicting effects as far as possible in a quantitative fashion to avoid incidental damage to environmental values that their managerial decisions might cause. NEPA requires major things to be considered in regards to the environment. "These policy statements invoke the need to fulfill, assure, attain, preserve, achieve, and enhance social and environmental values in conservation and renewable resources…". In theory, this provides for a great template balancing the economy with social and environmental issues. However, "The intent of NEPA also was blunted by agency reluctance and inability to adapt to new directives and to competition between agencies for NEPA-generated funds and tasks". Secondly, land management agencies often had no clue about the actual land content as they only managed for timber, grass, flood control, military ranges, etc. Quantifying biodiversity must always be a priority for biodiversity conservation. Lastly, if a controversy occurs, each side tries to demand the burden of proof from the other side. Obvious legal and administrative problems exist with the actual "jeopardy opinion", which results in the acceptance of the actual burden of proof.

Here another statement based on the huge experience by the authors with a high academic status that does not help to increase public trust in governmental actions when it comes to the environment and human welfare: "In a culture of public employees, every player must be aware, for welfare of self and dependants, that he/she is vulnerable. The higher people advance in the agency, the more they have to lose. On their own behalf, then, as well as their belief in the virtue of their organization, they will tend to place the welfare of their organization above any different good".

The book certainly presents in detail another global milestone in legislation introduced in 1971: The U.S. *Endangered Species Act* (ESA). But progress on recovery of endangered species is slow due to too many

bureaucratic hurdles, and due to a slow listing process and inadequate funding of the act. The authors make it very clear that for listing species in ESA, any economical considerations have to be ignored: it should be purely driven by decline and extinction concerns. But instead, and often due to financial constraints, right now 600 Category I species await listing, 3000 Category II species still await research and sound assessment "But environmentally ignorant politicians often, usually, reduce environmental budgets", and "The responsible services respond by emphasizing work on charismatic; i.e., glamour species ..." to obtain easier funds from the politically powerful urbanite. "Furthermore, by imposing a more rigorous standard of review, decisions of often technical scientific issues are shifted from an agency with substantial biological expertise, to judges who have none".

Habitat issues get well-covered, and authors promote co-management of the land. They show that it is a huge short-coming for wildlife that the United States has an ESA but not a Habitat or Ecosystem Act. As history showed already in United Kingdom, forest cover loss and human pressure resulted in severe declines of Aurochs, Forest Bison, Brown Bear, Wolf and Red Deer. In North America, Atlantic forests had been kept open by natives through the use of fire in November (as supported by the well-known fact that the first European seafarers detected land long before seeing it by smell). This type of land management favored the Heath Hen, Elk and Bison; but it all changed in an evolutionary eye blink with the advent of farmers. In the U.S., and due to the extent of the land, trespassing was hard to control and a charge for use was impossible. Thus, everybody could use the available game.

From 1982 onwards, the ESA requested that for each endangered species a Habitat Conservation Plan (HCP) had to be added in order to address critical habitat. This shifted now the burden of proof to the agency, which consequently resulted in only a few completed HCPs, so far.

This publication gives a nice overview of North American wildlife management history. Before ESA, most attention was given to game species only, since agencies were in charge dealing with game management. It is only since 1910 that every U.S. state actually has had a wildlife agency. The federal agency did not come into place before 1940 (USFWS: 1947 for Canadian Wildlife Service CWS). Five periods of Wildlife Management are presented: 1600-1849 era of abundance, 1850-1899 period of overexploitation, 1900-1929 period of protection, 1930-1965 game management and 1966 to present environmental management.

The International Wildlife Conservation Chapter I find an outstanding read also. The global goal still appears to turn everything into sustainable use; failures of TRAFFIC and CITES conventions in administering this movement are shown. Three goals of international conservation are: (i) preservation of species, (ii) integration of economic development and nature conservation, and (iii) effective cooperation of rural local people in wildlife conservation. Following this principle, authors present USAID as a development agency that has been heavily involved in hydro power projects world-wide. The roles of IUCN, Red Data Book, Survival Service Commission, WCMC, WWF and IWC get discussed in detail, too. A strong plea is made that U.S. should not withdraw from UNESCO (an agency that started with help from the English zoologist Julian Huxley, and which therefore included nature conservation within its scope).

This book shows that whatever happens in U.S. will eventually happen in Canada as well. It also shows that Canada is way behind when it comes to Wildlife Management, and that it is certainly not world-leading; e.g., the Canadian Environmental Protection Act got implemented as late as 1993. However, with Canada following U.S. almost blindly, at least consistency is assured across the North American continent; e.g., when compared to the diverse, if not even chaotic, policies in the European Union. The authors are not based in Canada, and some issues presented in the book for Canada sometimes appear a little too simplistic. Throughout the book, Canada gets portrayed as being similar to U.S., whereas U.S. has a much stronger NGO pressure than Canada has ever seen and experienced, making huge differences between the two countries. Despite the claim by the authors, Canada is definitely not further advanced in GIS and Satellite Imagery than U.S. (just have a look at the GAP programs for instance). From what I know, the Canadian Ecoregion approach to landscapes and management mentioned is actually very weak, to say the least.

This is an environmental history book *par excellence* but, unfortunately, without any relevant graphs, figures and maps. I am not a big fan of the reference organization either: references are not linked to the text and statements, and are hard to connect back from the text. Many chapters also have the same references cited several times. In some occasions, the text is a re-explanation of already published papers. The human welfare part could be stronger elaborated on, Adaptive Management principles by Carl Walters are hardly mentioned, nor any modern digital data issues for wildlife and habitats. For people with a European Union background, some of the related text sections might appear imprecise and blurred. At a few text sections, I am really at odds with the authors; for instance, they suggest that children had to be protected from wild predators, and that farming would have had negative effects on human life length and quality. Smaller errors can be forgiven (Domestication of African Elephants, Sperm Whale as the only large whale in tropical waters; U.K. being fully representative for Europe).

As a wildlife practitioner myself, I am extremely grateful that these two very experienced authors with highest academic ranking devote the book to "... students and field biologists acting under often trying

circumstances to strengthen the factual base for sustained positive relations between human and other forms of life." We need more of this, indeed. One might hope from this great book that Wildlife Managers will read, learn, and become environmentally considerate, eventually. But unfortunately, so far, the current facts and global political climate are just showing pure denial of facts presented in this book, suggesting another period of "intellectual stagnation". As a reviewer, I recommend all managers buy this book and implement its lessons learnt today.

FALK HUETTMANN

Institute of Arctic Biology, Biology and Wildlife Department, University of Alaska, Fairbanks Alaska 99775 USA

NEW TITLES

†Available for review * Assigned

Zoology

Amphibian Declines: The Conservation Status of United States Species. Edited by Michael Lannoo. 2005. University of California Press, 2120 Berkeley Way, Berkeley, CA 94704-1012. Distributed by NHBS2-3 Wills Road, Totnes, Devon TQ9 5XN, UK £62.00 Cloth

The Amphibians and Reptiles in Bulgaria. By V. Beshkov and K. Nanev. 2006. Pensoft Publishers, Geo Milev Street 13a 1111 Sofia, Bulgaria. 120 pages, Eur. 34.00

*** Antipredator Defenses in Birds and Mammals.** By T. Caro. 2005. The University of Chicago Press 1427 East 60th Street, Chicago, Illinois 60637 USA. 592 pages, U.S. $38

Retracing the Aurochs: History, Morphology and Ecology of an Extinct Wild Ox. By C. Van Vuure. 2005. Pensoft Publishers, Geo Milev Street 13a 1111 Sofia, Bulgaria. 424 pages, Eur. 54.90

The Return of the Beaver. By G. Sjoberg and J. Ball. 2006. Pensoft Publishers, Geo Milev Street 13a 1111 Sofia, Bulgaria. 300 pages, Eur. 67.90

A Systematic List of Extant Ground Beetles of the World (Coleoptera "Geadephaga": Trachypachidae and Carabidae, Incl. Paussinae, Cicindelinae, Rhysodinae). Second Edition. By W. Lorenz. 2005. Pensoft Publishers, Geo Milev Street 13a 1111 Sofia, Bulgaria. 530 pages, Eur. 135.00

To See Every Bird on Earth: a Father, a Son and a Lifelong Obsession. By Dan Koeppel. 2005. Hudson Street Press, published by Penguin Group. 304 pages, U.S.$24.95 Cloth.

*** Rare Bird: Pursuing the Mystery of the Marbled Murrelet.** By Maria Mudd Ruth. 2005. Rodale Press, 33 East Minor Street, Emmaus, Pennsylvania 18098-0099. 298 pages, U.S. $23.95 Cloth.

Birds of South Asia. The Ripley Guide. 2 volumes. By Pamela C. Rasmussen and John C. Anderton. 2005. Lynx Edicions, Montseny, 8, E-08193 Bellaterra, Barcelona, Spain. £55.00 Cloth

Cercopid Spittle Bugs of the New World (Hemiptera, Auchenorrhyncha, Cercopidae). By C. Carvalho and M. Webb. November, 2005. Pensoft Publishers, Geo Milev Street 13a 1111 Sofia, Bulgaria. 280 pages, Eur. 58.59.

Curassows and Related Birds. By Jean Delacour and Dean Amadon. (Original 1973. Revised by D. Brooks). 2005. Lynx Edicions, Montseny, 8, E-08193 Bellaterra, Barcelona, Spain. 476 pages, U.S. $75.

Ephemeroptera of South America. Aquatic Biodiversity of Latin America. (Abla Series) Number 2. By E. Dominguez, C. Molineri, M. Pescador, M. Hubbard, C. Nieto. 2006. Pensoft Publishers, Geo Milev Street 13a 1111 Sofia, Bulgaria. 490 pages, Eur. 95.00.

Fishes of the River Cai, Vietnam, Khanh Hoa Province. By D. Serov. 2005. Pensoft Publishers, Geo Milev Street 13a 1111 Sofia, Bulgaria. 164 pages, Eur. 33.00

Coastal Fishes of Southern Africa. By Phil Heemstra and Elaine Heemstra. 2005. National Inquiry Services Centre. Distributed by NHBS2-3 Wills Road, Totnes, Devon TQ9 5XN, UK 488 pages. £25.00 approximately U.S.$46

The Frogs of New Guinea and the Solomon Islands. By J. Menzies. 2006. Pensoft Publishers, Geo Milev Street 13a 1111 Sofia, Bulgaria. 210 pages. Eur 45.00

Evolution of the Insects. By David Grimaldi and Michael S. Engel. 2005. Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 2RU UK. Distributed by NHBS2-3 Wills Road, Totnes, Devon TQ9 5XN, UK £45.00 Cloth

Fascinating Insects. Some Aspects of Insect Life. By P. Jolivet and K.Verma. October, 2005. Pensoft Publishers, Geo Milev Street 13a 1111 Sofia, Bulgaria. 320 pages. Eur. 34.95

Great British Marine Animals. By Paul Naylor. 2005 . Sound Diving Publications, Distributed by NHBS 2-3 Wills Road, Totnes, Devon TQ9 5XN, UK. 272 pages. £15.00 paper.

An Atlas of the Reptiles of North Eurasia. By N. Ananjeva, N. Orlov, R. Khalikov, I. Darevsky, I. Ryabov and A. Barabanov, 2006. Pensoft Publishers, Geo Milev Street 13a 1111 Sofia, Bulgaria. 250 pages. Eur. 75.00

Botany

Illustrations of Alien Plants of the British Isles. By E. Clement, D. Smith and I. Thirlwell. 2005. Botanical Society of the British Isles, Botany Department, The Natural History Museum, Cromwell Road, London, SW7 5BD. 466 pages. £18.75 Paper, approximately U.S. $35

*** Plant Conservation – A Natural History Approach.** *Edited by* G. Krupnick and W. Kress. 2005. The University of Chicago Press 1427 East 60th Street, Chicago, Illinois 60637 USA. 344 pages. U.S.$30

Prairie Phoenix: The Red Lily in Saskatchewan. Edited by Bonnie J. Lawrence and Anna L. Leighton. 2005. Nature Saskatchewan, Room 206, 1860 Lorne Street, Regina, Saskatchewan S4P 2L7. 139 pages. $24.95 Cloth.

*** Giant Trees of Western North America and the World.** By A. Carder. 2005. Harbour Publishing, Box 219 Madeira Park, British Columbia V0N 2H0. 152 pages. $26.95 Paper.

*** Tropical Rainforests – past Present and Future.** By E. Bermingham. *Edited by* C. Dick and C. Moritz. 2005. The University of Chicago Press, 1427 East 60th Street, Chicago, Illinois 60637 USA. 672 pages. U.S. $45 Paper

Environment

Crooked Lake Biophysical Survey 2000. By C. and Deirdre Griffiths. 2005. Alberta Environmental Network, 1-6328A 104 Street NW, Edmonton, Alberta T6H 2K9. 330 pages. $90 (Postage and handling, add $10)

* **Ecology & Evolution in the Tropics: A Herpetological Perspective.** Edited by Maureen A. Donnelly, Brian I. Crother, Craig Guyer, Marvalee H. Wake, and Mary E. White. 2005. The University of Chicago Press, 1427 East 60th Street, Chicago, Illinois 60637 USA. 675 pages. U.S. $45.

Scientists Debate Gaia. Edited by S. Schneider, J. Miller, E. Crist, and P. Boston. 2005. MIT Press, Five Cambridge Center, 4th Floor, Cambridge, Massachusetts 02142-1493. 400 pages, US $ 50

An Ocean Odyssey. By Stephen Wong and Takako Uno. 2005. Distributed by NHBS2-3 Wills Road, Totnes, Devon TQ9 5XN, UK. 240 pages, £30.00 Cloth

One Planet, Many People: Atlas of Our Changing Environment. UNEP. Distributed by NHBS2-3 Wills Road, Totnes, Devon TQ9 5XN, UK. 320 pages, Hardcover £81.95 or download at http://www.na.unep.net/OnePlanetManyPeople/AtlasDownload.php

Tiger Bone and Rhino Horn – The Destruction of Wildlife for Traditional Chinese Medicine. By Richard Ellis. 2005. Distributed by NHBS2-3 Wills Road, Totnes, Devon TQ9 5XN, UK £16.95 paper

* **Sods, Soil, and Spades: Acadians at Grand Pre and their Dykeland Legacy.** By J. Sherman Bleakney. 2004. McGill-Queen's University Press, Montreal, Quebec. 221 pages, Can $106.99

News and Comment

The Boreal Dip Net/L'Epuisette Boreale: Newsletter of the Canadian Amphibian and Reptile Conservation Network/ Réseau Canadien de Conservation des Amphibiens et des Reptiles 9(3) July 2005

Editor's Note (Kerrie Serben) – Rounding up the facts on Roundup R (Bruce Pauli and Christina Howe – Queries to CARCNET – Life on the Info Line (David Galbraith) – Baby it's cold outside: Overwinter survival of Painted Turtle hatchlings (Elinor J. Hughes) – Interesting notes from Larry (Larry Halverson: Best management practices for amphibians and reptiles in urban and rural environments in BC; BC reptiles web site) – Blanding's Turtles are Endangered in Nova Scotia – Will frogs derail the Sea to Sky Highway? – Guidance for determining riparian zones (Christine Bishop) – Snake By D. H. Lawrence 1885-1930 (Sara Ashpole) – 10th Annual Meeting of CARCNET/RECCAR: Ottawa 15-19 September 2005.

– Membership in CARCNET/RECCAR is $20.00 (non-student) and $10 (student), and includes *The Boreal Dipnet*. Fees are due at the Annual Meeting (contact Bruce Pauli, Canadian Wildlife Service, National Wildlife Research Centre, Carleton University, Raven Road, Ottawa, Ontario K1A 0H3. Web site: http://www.carcnet.ca/).

Marine Turtle Newsletter (109)

July 2005. 28 pages: EDITORIAL: Tsunami Fund Update – GUEST EDITORIAL: An Economist's Reflections on the 25th Annual Symposium for Sea Turtle Biology and Conservation: Empirical Program Evaluation and Direct Payments for Sea Turtle Conservation – NOTES: Report of Olive Ridley Nesting on the North Coast of Trinidad – New Leatherback Conservation Project in Papua, Indonesia – A Note on the Illegal Trade in Stuffed Turtles in South Java, Indonesia – MEETING REPORTS – MTSG UPDATE – ANNOUNCEMENTS – OBITUARY – NEWS & LEGAL BRIEFS – RECENT PUBLICATIONS.

The Marine Turtle Newsletter is edited by Brendan J. Godley and Annette C. Broderick, Marine Turtle Research Group, Centre for Ecology and Conservation, University of Exeter in Cornwall, Tremough Campus, Penryn TR10 9EZ United Kingdom; e-mail MTN@seaturtle.org; Fax +44 1392 263700. Subscriptions and donations towards the production of the MTN can be made online at <http://www.seaturtle.org/mtn/> or postal mail to Michael Coyne (online Editor) Marine Turtle Newsletter, 1 Southampton Place, Durham, North Carolina 27705 USA (e-mail: mcoyne@seaturtle.org).

Minutes of the 126th Annual Business Meeting of The Ottawa Field-Naturalists' Club 11 January 2005

Place and time: Canadian Museum of Nature, Ottawa, Ontario, 7:30 p.m.
Chairperson: Mike Murphy, President
Attendance: Twenty-eight persons attended the meeting.

Attendees spent the first half-hour reviewing the minutes of the previous meeting, the Treasurer's Report and the Report of Council. The meeting was called to order at 7:40 p.m. with some opening remarks from Michael Murphy, the President.

1. Minutes of the Previous Meeting

There were no changes to the minutes of the 125th Annual Business Meeting.

It was moved by Fenja Brodo/Ron Bedford that the minutes be accepted.

(Motion Carried)

2. Business Arising from the Minutes

There was no business arising from the Minutes.

3. Communications Relating to the Annual Business Meeting

There were no communications relating to the Annual Business Meeting.

4. Treasurer's Report

Frank Pope reviewed the financial report for the year ending 30 September 2004, noting that the Club's net assets have increased by approximately $18 000. Most of this came in dedicated funds.

Moved by Frank Pope and seconded by Gillian Marston that the Financial Report be accepted.

(Motion Carried)

5. Committee Reports

Mike Murphy introduced each of the Committee reports and a representative of the appropriate Committee. After each report was read aloud, he asked for questions and comments. He thanked the committee chairs and committee members for their work over the past year.

Moved by David Hobden/Otto Loesel, that the reports be accepted with suggested ammendments.

(Motion Carried)

6. Nomination of the Auditor

Moved by Frank Pope, seconded by Dr. I. Brodo, that Janet Gehr continue as Auditor for another year.

(Motion Carried)

7. Report of the Nominating Committee

Fenja Brodo expressed thanks to Michael Murphy (President), Gillian Marston (Vice-President) and the rest of Council on behalf of the club. Special thanks were extended to Eleanor Zurbrigg.

President	Mike Murphy
Vice President	
Secretary	Susan Laurie Bourque
Treasurer	Frank Pope
Past President	Gary McNulty
Business Manager	Bill Cody
Editor CFN	Francis Cook
Editor T&L	Karen McLachlan Hamilton
Committee Chairs	
Birds	Chris Traynor
Computers	Eleanor Zurbrigg
Conservation	Stan Rosenbaum
E&P	Gillian Marston
E&L/Nominations	Fenja Brodo
Finance	Louise Schwartz
FWG	David Hobden
Membership	Dave Smythe
Publications	Ron Bedford
FON Rep	Cendrine Huemer

Members at large
Kathy Conlan
Diane Lepage
Diane Kitching
Henry Steger

Chairs not on Council

Awards	Ernie Brodo
Macoun	Rob Lee

Retiring from the council: John Cameron, Barbara Gaertner, Christina Lewis

New on the council: Eleanor Zurbrigg (returning), Diane Kitching

Moved by Fenja Brodo, seconded by Frank Pope, that the slate of nominations for the 2005 Council be accepted.

(Motion Carried)

8. New Business

There was no new business.

9. Presentation by Robert Lee, "Mary Stuart and the Macoun Club"

Rob Lee presented an enjoyable and touching presentation documenting the long and fruitful association between the late Mary Stuart and members of the Macoun Club. Mary owned a large property in the area of Pakenham which she generously allowed the Macoun Club to use as a destination for both field and camping trips. Rob showed many slides taken over the past thirty years, of her land and of Macoun members enjoying their time there. The slide show and Robs' narration were very well received by club members.

10. Adjournment

Moved by Henry Steger/Ron Bedford that the meeting be adjourned at 9:35 pm.

(Motion Carried)

SUSAN LAURIE-BOURQUE, Recording Secretary

The Ottawa Field-Naturalists' Club Committee Reports for 2004

Awards Committee

The Awards Committee met in January to consider nominations made for the various OFNC Awards. During the following weeks and months, numerous communications were held by e-mail and Canada Post as well as by phone. As a result of our deliberations, the following five awards for the year 2003 were presented at the OFNC's Annual Soirée, which took place 24 April 2004 at St. Basil's Church in Ottawa.

HONORARY MEMBER:

Daniel Strickland – for his renowned studies on Gray Jays, and for the major role that he has played in fostering an appreciation and enjoyment of natural history by the general public.

MEMBER OF THE YEAR:

Pearl Peterkin for her hard work on the *T&L* back-issue project as well as all her involvement with the Education and Publicity Committee.

GEORGE MCGEE SERVICE AWARD:

Colin Bowen for his extraordinary work on the Birds Committee over many years.

CONSERVATION AWARD – MEMBER:

Daniel Brunton for his role in the establishment of a new Canadian chapter of the RiverKeeper Alliance in Ottawa, and securing a full-time RiverKeeper to monitor the health and conservation of the Ottawa River.

CONSERVATION AWARD – NON-MEMBER:

Friends of the Jock River for their dedicated, inspired, hard-working and thoughtful approach to protecting the health of the Jock River and its watershed.

The full text of the citations for each of these awards was published in a previous issue of *The Canadian Field-Naturalist*.

I. BRODO

Birds Committee

The Birds Committee participated together with the Club des Ornithologues de l'Outaouais in another successful Christmas Bird Count in December 2003. The Fall Bird Count was held in late October 2004 and proved continuingly popular. The Committee was again active with the Peregrine Falcon Watch at the downtown nest site. For the first time, an information sign was displayed and a donations box was mounted. Over $200 was collected. Both falcon chicks fledged successfully tin 2004. The Bird Record Sub-committee met during the year to review records of rare birds for the area. Results of this work appear in *Trail & Landscape*. We continue to provide seasonal bird summaries for *Trail & Landscap*. The fourth year of surveying for the Ontario Breeding Bird Atlas (Region 24) has been completed. In 2004 the seed-a-thon raised over $600 in pledges for the OFNC's bird feeders. We continue to operate the rare bird alert and Ottawa's bird status line, which provides a recorded telephone message of current bird sightings. A new touch-tone feature added this year brings you directly to the most recent rare bird alert.

C. TRAYNOR

Computer Management Committee

The Computer Management Committee (CMC) has been without a Chairman during 2004 and the Committee has not met during the year. In the absence of a Chairman, the President has acted on behalf of the Chairman at Council for any matters that would normally be dealt with by the Committee.

In the almost 20 years since the CMC was first formed, there have been fundamental changes to computer technology such as the astonishing growth of the Internet and widespread use of personal computers by the general public.

Despite this, the OFNC continues to rely on the same suite of computer applications, such as the OFNC membership database and the desktop publishing systems used for the Club publication (*Trail & Landscape*). That so little change has been needed shows how well-founded these applications were. Due to its complexity and the variety of vital information products it must provide, the Membership Database is the application most needing renewal. Work has commenced on a replacement system.

It should be noted that many of the newer computer-related services used by the Club, such as the Club Website at (http://www.ofnc.ca) and e-mail addresses, have been established by Club volunteers without requiring direct involvement of the Computer Management Committee.

M. MURPHY

Conservation Committee

Larose Forest Francoscenie Proposal and Ontario Municipal Board Hearing

Stan Rosenbaum appeared as a participant witness to support the Friends of Larose Forest. OFNC approved payment of costs up to $1,000 to Federation of Ontario Naturalists for expert forestry witness Jim Faught, called by the Friends of Larose.

South Gloucester Lands (5309 Bank Street)

David Hobden represented OFNC at a City meeting. Numerous letters were sent to Ontario Ministry of Natural Resources and City Council, opposing quarrying and criticizing inadequate proposals to relocate rare species.

Alfred Bog

Frank Pope, chair of the Alfred Bog Committee, announced that the OMB appeal is abandoned and it now appears that Alfred Bog is protected.

Provincial Legislation Review

Workshops attended on the Planning Act, Provincial Policy Statement (PPS), and Ontario Municipal Board (OMB). Written briefs and letters sent to the Ontario Ministries of Municipal Affairs, Environment, Natural Resources and Agriculture, and the Premier, and to an EA Advisory Panel.

Constance Creek Wetland Donation Proposal

The owner has offered this 50-acre property to the FON. A site visit was made by Frank Pope and Stephen Derbyshire of OFNC, and Chris Grooms of FON.

S. ROSENBAUM

Education and Publicity Committee

The committee organized and managed OFNC participation in four public events: the Ottawa Teachers Federation elementary teachers' professional development day, 13 February 2004, the Carlingwood Wildlife Festival, 2 to 4 April; Telesat Canada's Health Fair (theme Go Green) 12 May; Health Canada's Celebration of Environment Week, 4 June. Arrangements were made for the judging and presentation of OFNC Natural History Awards at the Ottawa Regional Science Fair, 3 April. A nature photography contest for members was developed and details announced on the web-site and in volume 38 number 4 *Trail & Landscape*.

A portable display was developed and first used on a fall weekend in Mer Bleue. A French edition of the club brochure was published and distributed.

The sales table at the club's evening presentation at the Canadian Museum of Nature provided revenue of $528.

J. CAMERON

Excursions and Lectures Committee

In 2004 this Committee arranged 33 events, ten monthly meetings (including the Annual Business Meeting) and the Soirée. Of the 33 events, ten were general interest excursions, eight focused on birds, five on plants, five on invertebrates (butterflies, odonates, mollusca), two workshops (GPS and sketching) and four were museum trips. We hired buses for two of our trips: Presquile and the Biodôme in Montreal. Full day trips to interesting places remain the most popular and this year these included a walk in the Larose Forest (18 participants) and hiking up Luskville Falls (23 participants). Signed waiver forms allow us to track popularity of events.

Topics covered in our monthly meetings were insects (two talks), plants as de-contaminators, Australia, Petrie Island, canoeing down the Saskatchewan River, Macoun Marsh Project and the popular members slide night. An amusing video on penguins filled in for a cancelled speaker.

Council approved a budget of $200 for gifts/ honoraria to our speakers; the first was presented to our speakers in November 2004.

F. BRODO

Executive Committee

The Executive Committee met twice during 2004. The Committee discussed strategic planning matters such as governance, succession planning, and measures to address membership decline within the Ottawa Field-Naturalists' Club and the Macoun Field Club. Plans are also being developed to coordinate and acknowledge the efforts of volunteers, especially those who are new members.

M. MURPHY

Finance Committee

The Finance Committee met three times in 2003-04. Highlights include:

1. The Committee recommended to Council that no changes be made to the membership fee structure for 2005. Council approved this recommendation. Some concerns were noted about gradually declining membership and related revenue, operating deficits experienced over the past few years, and the reductions to the unrestricted reserve to cover these deficits.
2. A proposed budget for 2004-05 for the OFNC and the CFN was submitted to Council. A deficit of over $17 000 is forecast, and if realized will be a draw on the unrestricted reserve. Council approved this proposed budget.

During the year the Committee discussed the impact of changes in the federal government's Publication Assistance Program on mailing costs for *The Canadian Field-Naturalist* and *Trail and Landscape*, donations that qualify within our Registered Charity status, and governance issues associated with club liability.

L. SCHWARTZ

Fletcher Wildlife Garden

The year began with the signing of the first direct agreement between OFNC and Agriculture and Agri-food Canada concerning the operation of the Fletcher Wildlife Garden (FWG).

For the OFNC Annual Business Meeting, in January 2004, we made a digital presentation on the history and activities of FWG, which combined slides, prints and digital pictures. We had displays at the Ottawa Home Show and the Wildlife Festival and at a Festival workshop at the Museum of Nature. We staged our own International Migratory Bird event in conjunction with the Festival.

When the new gardening season began in April, all volunteers were provided with written safety instructions and asked to sign a waiver form. Volunteers contribute about 2500 hours each year. This summer three groups operated at different times.

In June, our annual plant sale included native plants grown by volunteers and by the Algonquin College Horticulture Program. It raised over $2000.

This year we were able to employ a full-time summer student, using a grant from Human Resources and Skills Development Canada. In addition to working with visitors, she reorganized the library and worked on invasive plant control.

Invasive plant control has concentrated on eliminating or reducing seed production by buckthorn and swallow-wort. We were warned that biocontrol would be the only effective long term control for swallow-wort, but it was at least ten years away. We have begun our own experiments on how best to contain the swallow-wort in the meantime. We have also used the web site and email to warn local government and community agencies of the problem.

Frank Pope completed two terms as FWG/OFNC representative on the Central Experimental Farm Advisory Committee and was replaced by Henry Steger.

D. HOBDEN

Macoun Field Club Committee

The Committee met once during the year and otherwise communicated regularly to plan the program for the children and young people during the year. Committee members supervised or gave presentations at 44 indoor meetings and led 15 field trips, as well as 2 camping trips.

The Club's annual publication, *The Little Bear*, was produced on time by one of the Senior members, without supervision, but the newsletter had to be taken over by one of the Committee members. Membership in the Senior group was faltering.

Type	Canadian				Foreign				Total	
	Local		Other		USA		Other			
Family	301	(317)	19	(23)	1	(1)	1	(1)	322	(342)
Individual	310	(323)	107	(111)	19	(24)	4	(6)	440	(464)
Honorary	14	(15)	10	(9)	0	(0)	0	(0)	24	(24)
Life	21	(21)	20	(20)	6	(7)	1	(1)	48	(49)
Sustaining	11	(11)	4	(3)	0	(0)	0	(0)	15	(14)
Total	657	(687)	160	(166)	26	(32)	6	(8)	849	(893)

Extensive renovations at the Victoria Memorial Museum Building required the Club to vacate the room where our collections and library had been housed for the past 20 years. Almost all the equipment and collections were put into storage with the Canadian Museum of Nature, with only the most essential materials being kept available in locked cabinets in the Museum's activity room. The entire library (1500 volumes) was moved to the home of one Committee member, and linked to a subject index on the Club's website, so that books remain available to members. The renovations are expected to last several years.

The Club's website continues to be developed by the Committee members, with some content (meeting and field-trip reports) being written by members.

R. LEE

Membership Committee

The distribution of memberships for 2004 is shown in the table (above), with the comparable numbers for 2003 in brackets. These statistics do not include the 23 affiliate organizations which receive free copies of the Club's publications.

This year, the Club lost a long time member and strong supporter of the Macoun Field Club with the death of Mary Stuart. Mary joined the Club in 1944 and was later given an Honorary membership for her contributions to the Club.

D. SMYTHE

Publications Committee

The Publications Committee met 3 times in 2004.

Four issues of *The Canadian Field-Naturalist* were published in 2004: Volume 117, #2, 3, 4 and Volume 118, #1. These four issues contained 702 pages; 59 articles; 28 notes; 95 book reviews; 115 new titles; 1 commemorative tribute; 20 pages of News and Comments; 1 page of miscellany; and a 30 page index. To commemorate the 125th anniversary of *The* OFNC, a 40 page history of The Club authored by Dan Brunton appears in Volume 118, #1. Only one article qualified for support from the Manning Memorial Fund for a total of $1440. The *CFN* is still running behind schedule; nevertheless a substantially higher number than in 2003 of articles, notes, and book reviews were published.

Volume 38 of *Trail & Landscape* was published in four issues containing 200 pages. Special red covers commemorated The Club's 125th anniversary. Greatest emphasis was on birds, the Fletcher Wildlife Garden, and Club affairs.

Publishing costs continue to increase, giving rise to financial concern for The Club.

R. BEDFORD

Auditor's Report

To The Members of THE OTTAWA FIELD NATURALISTS' CLUB

I have audited the balance sheet of THE OTTAWA FIELD-NATURALISTS' CLUB as at September 30, 2004, the statement of changes in net assets, and the statements of operations. These financial statements are the responsibility of the organization's management. My responsibility is to express an opinion on these statements based on my audit.

Except as explained in the following paragraph, I conducted my audit in accordance with Canadian generally accepted auditing standards. Those standards require that I plan and perform an audit to obtain reasonable assurance whether the financial statements are free of material misstatement. An audit includes examining evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation.

In common with many non-profit organizations, the Ottawa Field-Naturalists' Club derives some of its revenue from donations and fund raising activities. These revenues are not readily susceptible to complete audit verification, and accordingly, my verification was limited to accounting for the amounts reflected in the records of the organization.

In my opinion, except for the effect of the adjustments, if any, which I might have determined to be necessary had I been able to satisfy myself concerning the completeness of the revenues referred to in the preceding paragraph, these financial statements present fairly, in all material respects, the financial position of the OFNC as at September 30, 2004, and the results of its operations and changes in net assets for the year then ended in accordance with Canadian generally accepted accounting principles.

JANET M. GEHR
Chartered Accountant

North Gower, Ontario
3 January 2005

The Ottawa Field-Naturalists' Club
Balance Sheet
September 30, 2004

	2004	2003
ASSETS		
CURRENT		
Cash (Note 1)	$ 22,306	$ 2,781
Investment certificates (Note 1)	29,175	43,764
Marketable securities (Note 2)	261,050	246,467
Accounts receivable	16,703	27,690
Prepaid expenses	1,000	1,000
	330,234	321,702
CAPITAL ASSETS (Note 3)	–	–
LAND – ALFRED BOG	3,348	3,348
	333,582	$ 325,050
LIABILITIES AND FUND BALANCES		
CURRENT		
Accounts payable and accrued liabilities	$ 2,000	$ 2,000
Deferred revenue	11,714	12,075
	13,714	14,075
LIFE MEMBERSHIPS	13,607	12,663
NET ASSETS		
Unrestricted	62,667	60,609
Club reserve	100,000	100,000
Manning principal	100,000	100,000
Manning interest - OFNC	2,457	1,434
- CFN	15,805	13,153
Seedathon	1,281	1,618
Anne Hanes memorial	870	870
de Kiriline-Lawrence	18,429	18,798
Macoun Baillie Birdathon	1,052	1,337
Alfred Bog	3,700	493
	306,261	298,312
	333,582	$ 325,050

The Ottawa Field-Naturalists' Club
Statement of Operations
For the Year Ended September 30, 2004

	2004	2003
REVENUE		
Memberships	$ 13,969	$ 14,615
Trail and Landscape	280	196
Interest	1,835	1,339
GST rebate	768	780
Fletcher Wildlife Garden (Note 4)	1,734	–
Other	373	617
	18,959	17,547
OPERATING EXPENSES		
Affiliation fees	670	680
Computer	1,294	302
Membership	1,168	1,151
Office Assistant	1,000	1,000
Telephone	1,640	1,622
Insurance	725	655
Audit	1,000	1,000
GST	1,214	1,290
Other	952	884
	9,663	8,584
CLUB ACTIVITY EXPENSES		
Awards	150	–
Birds	540	1,696
Education and Publicity	775	73
Excursions and Lectures	(508)	496
Macoun Field Club	606	851
Soiree	270	19
Trail and Landscape	9,578	8,368
Fletcher Wildlife Garden (Note 4)	–	2,623
Other	84	–
	11,495	14,126
	21,158	22,710
EXCESS EXPENSES OVER REVENUE	$ (2,199)	$ (5,163)

The Ottawa Field-Naturalists' Club
Canadian Field-Naturalist — Statement of Operations
For the Year Ended September 30, 2004

	2004	2003
REVENUE		
Memberships	$ 9,313	$ 9,743
Subscriptions	23,936	25,369
Reprints	5,574	9,534
Publication charges	23,685	50,559
Interest and exchange	8,290	7,940
GST rebate	3,889	3,040
Other	1,477	734
	76,164	106,919
EXPENSES		
Publishing	46,385	$ 80,758
Reprints	2,141	7,307
Circulation	6,442	11,307
Editing	3,587	4,183
Office Assistant	5,000	5,000
Honoraria	9,000	9,000
GST rebate	4,203	6,508
Other	65	552
	76,823	124,615
EXCESS EXPENSES OVER REVENUE	$ (659)	$ (17,696)

The Ottawa Field-Naturalists' Club Notes to the Financial Statements
September 30, 2004

1. CASH

	2004	2003
Chequing	$ 11,899	$ (3,777)
Savings	4,491	1,344
Nesbitt Burns	–	919
Fletcher Wildlife Garden	5,916	4,295
	$ 22,306	$ 2,781

Investment Certificates:	Maturity Value	Maturity Date	Yield	Book Value
	$ 29,402	04/29/05	1.35%	$ 29,175

2. MARKETABLE SECURITIES

Investment Certificates:	Maturity Value	Maturity Date	Yield	Book Value
Province of Newfoundland Coupon	$ 44,782	10/17/11	4.525%	$ 32,965
Province of Ontario Coupon	15,376	12/02/12	4.591%	10,601
Province of Manitoba Coupon	29,847	11/15/04	5.119%	27,939
Ontario Savings Bonds	40,000	06/21/05	6.45%	41,370
CMHC Global Debs	52,000	12/01/06	5.250%	53,539
Province of Ontario Bond	30,000	09/12/07	6.125%	31,187
Province of Newfoundland Bond	20,000	10/07/08	6.263%	20,538
Government of Canada Coupon	30,167	12/01/09	5.605%	21,843
Province of New Brunswick Bond	20,000	06/15/10	6.231%	21,068
				$261,050

3. CAPITAL ASSETS
Equipment at a cost of $16,748 is fully amortized.

4. FLETCHER WILDLIFE GARDEN

	2004	2003
REVENUE		
Human Resources and Skills Dev. Canada	$ 2,892	–
TD Friends of the Environment Fund	2,888	–
Taverner Cup	418	1,068
Sales	3,376	–
GST	144	180
Donations	476	50
Other	0	2,425
	10,194	3,723
EXPENSES		
Program	3,664	2,318
Backyard	2,176	1,362
Habitats	737	920
Interpretation centre	130	118
Administration	693	944
Publications	799	309
GST	261	243
Library	–	132
	8,460	6,346
	$ 1,734	$ (2,623)

The Ottawa Field-Naturalists' Club Statement of Changes in Net Assets
For the Year Ended September 30, 2004 (Note 5)

Net Assets	Beginning Balance	Excess Expenses CFN	Excess Expenses OFNC	Other Revenue	Expenses	2004 Ending Balance
Unrestricted	$ 60,609	$ (659)	$ (2,199)	$ 4,916	$ –	$ 62,667
Club Reserve	100,000	–	–	–	–	100,000
Manning Principal	100,000	–	–	–	–	100,000
Manning - OFNC	1,434	–	–	1,023	–	2,457
Manning - CFN	13,153	–	–	4,092	1,440	15,805
Seedathon	1,618	–	–	623	960	1,281
Anne Hanes Memorial	870	–	–	–	–	870
de Kiriline-Lawrence	18,798	–	–	631	1,000	18,429
Macoun Baillie Birdathon	1,337	–	–	115	400	1,052
Alfred Bog	493	–	–	3,207	–	3,700
	$ 298,312	$ (659)	$ (2,199)	$ 14,607	$ 3,800	$ 306,261

5. STATEMENT OF CHANGES IN NET ASSETS

a) Manning *CFN* Expenses: Volume 117, Number 3, Cody, Reading and Line, Additions and range extensions to the vascular plant flora of the continental NWT and Nunavut, Canada, II.
b) Seedathon Expenses: birdseed for club feeders.
c) Louise de Kiriline Lawrence Expenses: Contribution to the defense of the Larose Forest at a hearing of the Ontario Municipal Board.
d) Macoun Baillie Birdathon: a digital camera with accessories.

The Ottawa Field-Naturalists' Club Summary of Significant Accounting Policies

September 30, 2004

1. Nature of Business

The organization is non-profit and incorporated under the laws of Ontario (1884). The organization promotes the appreciation, preservation, and conservation of Canada's natural heritage. It encourages investigation and publishes the results of the research in all fields of natural history and diffuses information on these fields as widely as possible. It also supports and cooperates with other organizations engaging in preserving, maintaining or restoring environments of high quality for living things.

2. Financial Instruments

The organization's financial instruments consist of cash, accounts receivable, marketable securities, and accounts payable. Unless otherwise noted, it is the management's opinion that the organization is not exposed to significant interest, currency, or credit risks arising from these financial instruments. The fair value of these instruments approximate their carrying values.

3. Capital Assets

Capital assets acquired after 1989 are expensed. Capital assets acquired prior to 1990 were recorded as assets at cost and amortized on a stright-line basis. These assets have been fully amortized.

4. Statement of Changes in Financial Position

A statement of changes in financial position has not been provided as it would not provide additional meaningful information.

5. Foreign Currency

Transactions during the year in U.S. dollars have been converted in the accounts to Canadian dollars at the exchange rate effective at the date of the transaction. All monetary assets in U.S. dollars at year end have been converted to Canadian dollars at the rate effective on Sept. 30 2004. Gains or losses resulting therefrom are included in revenue or expenses.

Advice for Contributors to *The Canadian Field-Naturalist*

Content

The Canadian Field-Naturalist is a medium for the publication of scientific papers by amateur and professional naturalists or field-biologists reporting observations and results of investigations in any field of natural history provided that they are original, significant, and relevant to Canada. All readers and other potential contributors are invited to submit for consideration their manuscripts meeting these criteria. The journal also publishes natural history news and comment items if judged by the Editor to be of interest to readers and subscribers, and book reviews. Please correspond with the Book Review Editor concerning suitability of manuscripts for this section. For further information consult: A Publication Policy for the Ottawa Field-Naturalists' Club, 1983. *The Canadian Field-Naturalist* 97(2): 231-234. Potential contributors who are neither members of The Ottawa Field-Naturalists' Club nor subscribers to *The Canadian Field-Naturalist* are encouraged to support the journal by becoming either members or subscribers.

Manuscripts

Please submit, **to the Editor,** in either English or French, **three** complete manuscripts **written in the journal style.** The research reported should be original. It is recommended that authors ask qualified persons to appraise the paper before it is submitted. All authors should have read and approved it. Institutional or contract approval for the publication of the data must have been obtained by the authors. Also authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants or minerals. The place where voucher specimens have been deposited, and their catalogue numbers, should be given. Latitude and longitude should be included for all individual localities where collections or observations have been made.

Print the manuscript on standard-size paper, **doublespace throughout,** leave generous margins to allow for copy marking, and **number each page.** For Articles and Notes provide a citation strip, an abstract and a list of key words. Generally, words should not be abbreviated but use SI symbols for units of measure. The names of authors of scientific names may be omitted except in taxonomic manuscripts or other papers involving nomenclatural problems. "Standard" common names (with initial letters capitalized) should be used at least once for all species of higher animals and plants; all should also be identified by scientific name.

The names of journals in the Literature Cited should be written out in full. Unpublished reports and web documents should not be cited here but placed in the text or in a separate Documents Cited section. List the captions for figures numbered in arabic numerals and typed together on a separate page. Present the tables each titled, numbered consecutively in arabic numerals, and placed on a separate page. Mark in the margin of the text the places for the figures and tables.

Check recent issues (particularly Literature Cited) for journal format. Either "British" or "American" spellings are acceptable in English but should be consistent within one manuscript. **The Oxford English Dictionary, Webster's New International Dictionary** and le **Grand Larousse Encyclopédique** are the authorities for spelling.

Illustrations

Photographs should have a glossy finish and show sharp contrasts. Electronic versions should be high resolution. Photographic reproduction of line drawings, **no larger than a standard page,** are preferable to large originals. Prepare line drawings with India ink on good quality paper and letter (don't type) descriptive matter. Write author's name, title of paper, and figure number on the lower left corner or on the back of each illustration.

Reviewing Policy

Manuscripts submitted to *The Canadian Field-Naturalist* are normally sent for evaluation to an Associate Editor (who reviews it or asks another qualified person to do so), and at least one other reviewer, who is a specialist in the field, chosen by the Editor. Authors are encouraged to suggest names of suitable referees. Reviewers are asked to give a general appraisal of the manuscript followed by specific comments and constructive recommendations. Almost all manuscripts accepted for publication have undergone revision—sometimes extensive revision and reappraisal. **The Editor makes the final decision** on whether a manuscript is acceptable for publication, and in so doing aims to maintain the scientific quality, content, overall high standards and consistency of style, of the joumal.

Special Charges — Please take note

Authors **must share in the cost of publication** by paying $80 for each page, plus $15 for each illustration (any size up to a full page), and up to $80 per page for tables (depending on size). Authors may also be charged for their changes in proofs. Reproduction of colour photos is extremely expensive; price quotations may be obtained from the Business Manager. If grant or institutional funds are not available, club members and subscribers may apply for a waiver of charges for the first five pages.

Limited joumal funds are available to help offset publication charges to authors with minimal financial resources. Requests for financial assistance should be made to the Business Manager when the manuscript is accepted.

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An order form for the purchase of reprints will accompany the galley proofs sent to the authors.

FRANCIS R. COOK, Editor
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ISSN 0008-3550

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The CANADIAN FIELD-NATURALIST

Published by THE OTTAWA FIELD-NATURALISTS' CLUB, Ottawa, Canada

Volume 119, Number 4

October–December 2005

The Ottawa Field-Naturalists' Club

FOUNDED IN 1879

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Her Excellency The Right Honourable Michaëlle Jean
Governor General of Canada

The objectives of this Club shall be to promote the appreciation, preservation and conservation of Canada's natural heritage; to encourage investigation and publish the results of research in all fields of natural history and to diffuse information on these fields as widely as possible; to support and cooperate with organizations engaged in preserving, maintaining or restoring environments of high quality for living things.

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The Canadian Field-Naturalist

The *Canadian Field-Naturalist* is published quarterly by The Ottawa Field-Naturalists' Club. Opinions and ideas expressed in this journal do not necessarily reflect those of The Ottawa Field-Naturalists' Club or any other agency.

PAP Registration Number 9477. Canada We acknowledge the financial support of the Government of Canada through the Publication Assistance Program (PAP) toward our mailing costs.

All manuscripts intended for publication except Book Reviews should be addressed to the Editor and sent by postal mail. Book-review correspondence should be sent by e-mail or postal mail to the Book-review Editor.

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COVER: A "Prairie Grouse": Greater Prairie Chicken × Sharptailed Grouse, *Tympanuchus cupido* × *phasianellus* at the Sheguiandak lek, Manitoulin Island, Ontario, photographed early May 1961. See papers by Harry G. Lumsden pages 507-514 and 515-524.

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The Canadian Field-Naturalist

Volume 119, Number 4 October–December 2005

Breeding and Non-Breeding Range of Canada, *Branta canadensis*, and Cackling Geese, *Branta hutchinsii*, in the Eastern Canadian Arctic

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Mallory, Mark L., Alain Fontaine, and Hugh Boyd. 2005. Breeding and non-breeding range of Canada, *Branta canadensis*, and Cackling Geese, *Branta hutchinsii*, in the eastern Canadian Arctic. Canadian Field-Naturalist 119(4): 483-489.

The accepted breeding distribution of Canada Geese from the Atlantic Population (*Branta canadensis interior*) in the eastern Canadian Arctic is currently confined to northern Québec and the south coast of Baffin Island. Here we provide evidence based on observations from scientific studies, Inuit hunters, and territorial Wildlife Officers that *B. c. interior* now breeds in growing numbers 500 km farther north on northeastern Baffin Island than previously reported. Cackling Geese (*B. hutchinsii*), which breed more widely across eastern Arctic Canada, to about 72°N, may also be increasing there. Moreover, individuals of both species are seen occasionally as far north as Ellesmere Island in small flocks and within migrating or moulting flocks of Snow Geese (*Chen caerulescens*) or Brant (*B. bernicla hrota*), though none of these far northern stragglers are known to have bred. Whether these observations reflect a recent range expansion or improved distributional knowledge from more intensive recent survey efforts remains unknown.

Key Words: *Branta canadensis*, Canada Goose, *Branta hutchinsii*, Cackling Goose, breeding, distribution, Arctic

Our knowledge of the distribution of breeding birds in the Canadian Arctic is based largely on reports from early explorers (e.g., Parry 1824; Nansen 1897), from initial scientific survey efforts (e.g., Duvall and Handley 1948*; Ellis and Evans 1960; Manning 1976), and from more recent aerial reconnaissance (e.g., Nettleship 1974; McLaren 1982; Gaston et al. 1986). Some long-term studies have also provided insights into annual variation in species that breed in certain areas (e.g., Gaston and Ouellet 1997; Lepage et al. 1998). While many gaps in our knowledge of breeding bird distributions in the Arctic remain, it is now clear that distributions of some birds in the Arctic are changing. For example, Snow Goose (*Chen caerulescens*) colonies have expanded markedly in the past 30 years; breeding now occurs in new areas or at higher densities than previously recorded, in some cases seriously degrading habitats (Mowbray et al. 2000). Ross's Geese (*Chen rossi*) now breed farther east in Nunavut and in greater numbers than they did 20 years ago (Ryder and Alisauskas 1995). In addition, satellite telemetry has shown that some Canada Geese (*Branta canadensis*) use southeastern Baffin Island as a stopover point en route to their breeding areas in Greenland (Scribner et al. 2003).

The breeding distribution of different populations of Canada Geese in the eastern Canadian Arctic has recently undergone extensive review (Dickson 2000a; Canadian Wildlife Service Waterfowl Committee 2003; Boyd and Dickson *in* Kear 2004). Even more recently, the American Ornithologists' Union (Banks et al. 2004) decided to split Canada Geese into two species, separating the small Cackling Geese, *B. hutchinsii,* from the larger forms of *B. canadensis*. Two breeding populations of these types of similar geese can be commonly found north of 60° in eastern Nunavut. In the Kivalliq region and around Foxe Basin, the Tallgrass Prairie Population dominates, which is principally composed of Cackling Geese (Bellrose 1980; Dickson 2000b). Some of the Atlantic Population geese (mostly *B. c. interior*, a larger race of Canada Goose) that breed in northern Québec may breed in southwestern Baffin Island. Although the North Atlantic Population (*B. c. canadensis*, also a larger race of Canada Goose) breeds in northern Labrador, it is not reported to breed on Baffin Island. To the east across Baffin Bay, Canada Geese breeding in western Greenland are morphologically and genetically similar to the Atlantic population (Fox et. al. 1996; Scribner et al. 2003).

We have combined breeding range data from a variety of sources in Figure 1 to show the current, accepted, northern portion of the breeding distribution of Canada and Cackling geese (Bellrose 1980; Reed et al. 1980; Godfrey 1986; Dickson 2000b; Mowbray et al. 2002). Godfrey (1986) mentioned that some geese were thought to breed on the Cumberland Peninsula, without confirmation. This note deals chiefly with new information on the distribution and probable range expansion of the Atlantic Population of *B. c. interior* into the eastern Canadian Arctic islands. It has also moved into west Greenland, where its numbers have grown rapidly in the last 30 years (Fox et al. 1996; Malecki et al. 2000; Scribner et al. 2003). This new information suggests that current range maps require revision.

Methods

Much of the information on the breeding range of Canada and Cackling geese reported here came from Inuit hunters, including verified data from the five-year Nunavut Wildlife Harvest Study (Priest and Usher 2004). This harvest study required hunters to identify the number, location and date of animals (in this case, geese and/or eggs) harvested, and these records were subsequently verified by field technicians. These results were then summarized and published (Priest and Usher 2004), such that results for a community represent harvest in that year within the hunting region around that area. Other data were also collected as part of local ecological knowledge studies focused on various subjects during discussions with Inuit hunters and Wildlife Resource Officers in communities along Baffin Bay (e.g., Mallory et al. 2003). Local knowledge has proven to be an effective means of examining wildlife distributions in the Arctic, as Inuit are keen observers of their environment (Gilchrist et al. 2005*).

The other main sources of data were incidental observations by MLM and AJF in the course of ground- and boat-based surveys of other migratory bird species between 2000 and 2004 (Fontaine et al. 2001; Mallory et al. *in review*). Scattered published and unpublished materials collected by other biologists during non-systematic aerial surveys of the Queen Elizabeth Islands and coastlines of Lancaster and Jones Sound in 1968-1969 and 1971 amplify some of those records (e.g., Heyland and Boyd 1969*; HB). In these cases, "large" or "small" geese were typically identified by the relative size of their head and neck, or their body size in relation to nearby birds (e.g., Snow Geese). There have been no systematic surveys to determine the distribution of Canada or Cackling geese in the eastern Canadian Arctic. However, portions of the breeding population have been assessed directly (e.g., Malecki and Trost 1990), as part of colony surveys for Snow Geese (D. Caswell, personal communication), or in some other bird survey projects (e.g., Johnston et al. 2000).

Results

Reports by Inuit hunters

In discussions with hunters in eastern Nunavut, we received reports on Canada Geese near various communities. Hunters in Iqaluit (63°45'N 68°30'W) have observed increases in the number of large Canada Geese upon islands and hillsides of Frobisher Bay. In Pangnirtung (66°30'N 66°W), Inuit hunters and National Park wardens stated that numbers of geese in Cumberland Sound have increased dramatically since the 1970s, and that some birds breed in the area, often at eider colonies. Further north, hunters from Qikiqtarjuaq (67°30'N, 64°W) told us about harvesting adult geese and their eggs near Cape Searle (67°14'N, 62°28'W) and Reid Bay (66°56'N, 61°46'W), the same area where we observed breeding geese during our field studies (below). At Clyde River (70°45'N, 68°W), local hunters observe and harvest medium to large-sized geese. In Arctic Bay (73°02'N, 85°10'W), hunters shoot adult small geese, presumably *B. hutchinsii*, but local breeding has not been confirmed, although Cackling Geese do breed near southern Admiralty Inlet (Figure 1).

Results from the Nunavut Wildlife Harvest Study support the local ecological knowledge shared with us by Inuit hunters. Between 1996 and 2001, adult geese (apparently large geese, hence Canada Geese) were harvested by hunters from the communities of Iqaluit, Pangnirtung, Qikiqtarjuaq, Clyde River, Pond Inlet, Resolute Bay, and Grise Fiord (Figure 1; Priest and Usher 2004). Harvest of Canada Geese was not reported at Grise Fiord between 1956 and 1972 (Riewe 1977). The magnitude of the annual harvest decreases as one moves north from Iqaluit to Resolute, with approximately 350 Canada Geese harvested each year among these communities (Priest and Usher 2004). An estimated 350 Canada Goose eggs are collected annually among residents of Iqaluit, Pangnirtung, Qikiqtarjuaq and Clyde River (Priest and Usher 2004), confirming breeding near these communities.

Other observations of breeding Canada Geese

During surveys of breeding marine birds along the coastline of Frobisher Bay and Cumberland Sound in August 2000, Canada Geese were seen frequently in lowland arctic meadows and on grassy hillsides facing the coast (Fontaine et al. 2001), many of them with young of the year (J. A. Akearok, personal communication). In other breeding bird surveys along the north shore of Frobisher Bay in July 2001 and 2002, numerous other flocks of adults, as well as paired nesting Canada Geese were observed (MLM). In June 2000 to 2004, numerous small flocks of paired birds with no young were observed near the Iqaluit airport and in nearby inland valleys. Hence, geese in the Frobisher Bay area appear to be a mix of breeding birds, failed breeders and moult migrants, all of medium to large races.

FIGURE 1. Known range (shaded) and new location observations (dots) of Canada (*Branta canadensis*) and Cackling geese (*Branta hutchinsii*) in eastern Nunavut, Canada. The existing range represents a composite of information from a variety of published sources. Note that solid triangles for Canada Goose harvest include harvest of adults and/or eggs, and do not differentiate between Canada Geese and Cackling Geese.

On 11-14 June 2001, we also observed approximately 50 nesting Canada Geese on the northern Cumberland Peninsula near Merchants Bay (67°20'N, 62°30'W). Inuit at a local outpost camp had been harvesting Canada Goose eggs for a week; there were at least 12 eggs in a bucket at the camp on 11 June. Another 18 pairs of breeding geese were seen on 7 June 2002 on nearby Qaqulluit Island (67°12'N, 62°33'W). During the trips from Qikiqtarjuaq to Qaqulluit Island, other Canada Geese were often flushed from heath slopes and lowlands along the 100-km route. All the geese in this region were large, suggesting *B. c. interior* affinities.

On southern Bylot Island (73°N, 78°W), J. D. Heyland (personal communication) found nesting geese each year from 1969-1971. Most of them were small, apparently Cackling Geese, but in 1970 a larger pair bred successfully (JDH and HB). A photograph taken before 1937 at Pond Inlet shows a local Inuit woman with Snow Geese and one Cackling Goose harvested nearby (A. Reed, personal communication). Lepage et al. (1998) saw flocks of small, Cackling Geese on Bylot Island almost every year between 1979 and 1997, and confirmed breeding on three occasions. They also saw five larger birds that they suggested were *B. c. interior.* C. Machtans flushed a Canada Goose of un-

recorded size off a nest containing four eggs on 28 June 1997 at Creswell Bay (72°50'N, 93°11'W) on Somerset Island (C. Machtans, unpublished data). Its mate was in the vicinity and other geese (approximately four) were also observed but details concerning breeding status were not recorded.

Cackling or Canada geese were seen in appreciable numbers along the east and west coasts of Foxe Basin in 1979 (Reed et al. 1980), but not on the islands in the Basin. In 1987 and 1988, small numbers of medium-sized geese bred on Rowley Island (69°N, 78°W; Boyd 1989). The parents of one brood were noticeably larger than those of a second brood. As none were caught and measured, it was not possible to determine the species involved. In 1989, at least five pairs of small geese (*B. hutchinsii*) were seen at nests in the northwest of Prince Charles Island (Boyd 1999).

Adult Cackling and Canada geese in the Queen Elizabeth Islands

A flightless dark goose was seen among a flock of 20 flightless Snow Geese at the north end of Vendom Fiord, Ellesmere Island (77°40'N, 82°30'W) on 26 July 1968, and another in a flock of 70 Snow Geese on a small lake near Goose Fiord (76°57'N, 88°45'W), on 8 August 1971 (HB). They were smaller than the Snow Geese, suggesting *B. hutchinsii*. No Canada Geese were seen on extensive aerial surveys of Devon and Ellesmere islands, nor along the coast of northwestern Greenland, in 1969.

On 10 June 2003, a single, large race Canada Goose was photographed with a flock of Eastern High Arctic Brant (*B. bernicla hrota*) at Cape Vera, northern Devon Island (76°15'N, 89°15'W). Two days later, another single goose was photographed at this site, again within a flock of Brant, but on this occasion the bird was clearly a Cackling Goose (AJF). This bird stayed at the site for over a week and was attempting to establish a pair bond with one of the Brant. Two more Canada Geese were observed at Cape Vera in 2004, one single bird on 30 May and another on 7 June. Unfortunately, no data on size or flock association were recorded.

In Quttinirpaaq National Park on northern Ellesmere Island, park wardens report having seen Canada Geese of unknown size in the vicinity of Lake Hazen (81°47'N, 71°03'W): one lone bird on 3 June 2001 and another on 1 July 2002.

Interestingly, Duvall and Handley (1948*) recorded no Canada Geese in southwestern Ellesmere Island in 1947, and Prach (1986*) reported none in five years of study at Cape Vera between 1980 and 1984. Nor were any Canada Geese observed during long-term studies on Prince Leopold Island (74°N, 90°W) from 1988 to 2004 (Nettleship et al. 1990; A. J. Gaston, personal communication), during aerial marine surveys in 1977 in Lancaster Sound (Nettleship and Gaston 1978), during ecological research studies in the Truelove Lowlands on northeastern Devon Island (75°41'N, 84°35'W) in 1966-1969 and 1971-1974 (Hussell and Holroyd 1974; Pattie 1977), nor at Alexandra Fiord on eastern Ellesmere Island (78°53'N, 75°55'W) in annual studies since 1982 (G. Henry, personal communication).

Discussion

Dickson (2000b:12) noted that "As a species, *Branta canadensis* is doing well and increasing rapidly in abundance and range". The new reports and observations presented here suggest that indeed the known breeding range of the Canada Goose in the eastern Canadian Arctic should be revised and extended at least 500 km further north along the northeast coast of Baffin Island from currently published limits.

The breeding range of *B. c. interior* has long been known to extend to the south coast of Baffin Island (Palmer 1976; Bellrose 1980). We suspect that geese breeding along the eastern Baffin Island coast are all larger race, probably part of the Atlantic (*B. c. interior*) population, given that this population migrates through this region to Greenland (Scribner et al. 2003). Canada Geese reported breeding on Bylot Island (Lepage et al. 1998) are thought to include both Atlantic Population geese as well as Cackling Geese, the latter presumably of the Tallgrass Prairie Population known to breed in central Nunavut and on western Baffin Island around Foxe Basin. Geese breeding in Creswell Bay are most likely from the latter population. The Tallgrass Prairie Population is believed to be increasing and these breeding records extend their range by a distance of about 300 km to the north and 200 km to the northeast (Dickson 2000b).

Given that Canada Geese were encountered along many hillsides in Frobisher Bay and south from Qikiqtarjuaq during our surveys, it is likely that the distribution of geese along the eastern coast of Baffin Island is sparse and fragmented at least as far north as Clyde River. The numbers breeding along the coast north of Clyde River will likely never become large, because the Arctic Cordillera holds only a few small pockets of potential feeding sites for geese, on wet meadows at the inner ends of fiords. The greatest scope for further expansion may lie in the west of Baffin Island, especially in the lakes and marshes of the Gifford River basin (70°30'N, 84°W), where Greater Snow Geese began to breed in the 1980s, after using it as a moulting area since at least the 1960s. That area, outside the usual range of Inuit goose hunters, though visited by them in winter, has not been searched for geese for many years. Moreover, Canada Geese have been observed as far north as northern Ellesmere Island, and thus non-breeders may inhabit suitable habitats across the coastal areas of Ellesmere, Devon and northern Baffin islands.

It is likely that some Canada Geese have frequented these areas for many years, at least as non-breeding or moulting birds, as suggested by some earlier survey efforts and by Inuit hunters who have reported seeing

increases in the number of Canada Geese in the past 30 years. Because much of this area was glaciated as recently as 4000 years ago, Canada Geese probably were not in the area until long after the last glacial period (Dickson 2000b). Suitable breeding habitat is patchily distributed along eastern Baffin Island, as much of the region is part of the Arctic Cordillera and supports limited, suitable vegetation for goose forage. The goose habitat is probably similar to Greenland, where Canada Geese are distributed in areas with low snow cover and where snow disappears first in the spring (Malecki et al. 2000).

Why then have goose numbers increased in these regions? Although many Canada Goose populations in North America are steadily increasing, trends in population size for the Atlantic and North Atlantic Populations have highly fluctuated in recent years (Dickson 2000b). The Atlantic Population of *B. c. interior*, which is doubtfully distinguishable based on morphology from the North Atlantic Population (*B. c. canadensis*) breeding chiefly in Labrador, decreased from an estimated 120 000 breeding pairs in 1988 to about 30 000 pairs in 1995. When that decrease became obvious on its wintering range, chiefly in and around Maryland, the American hunting season was closed for several years, and the season and bag limit in southern Québec and Ontario were reduced. Those measures resulted in a rapid recovery of the breeding population and its expansion to around 160 000 breeding pairs in 2002 and 2003 (CWS 2003), at which time hunting restrictions were relaxed. That expansion seems to have fuelled the growth of the breeding population in the Kangerlussuaq region (67°N, 50°W) of western Greenland which has been growing since the 1970s (Kristiansen et al. 1999), to now more than 2600 pairs (Malecki et al. 2000). Intuitively, it would appear that this expansion may account for the recent increase on Baffin Island as well. It is also possible that the moult migrations from increasing goose populations in areas in the south have led to the initiation of breeding in new areas in the Arctic (Mowbray et al. 2002). Still, our recent investigation did not allow us to determine whether the observed extension of breeding range represents a recent expansion, or rather a more complete record based on more intensive research along this coast in the past decade. Irrespective of the cause, it is clear that Canada Geese breed much further north on eastern Baffin Island than previously reported in the literature.

Cackling Geese breed abundantly on the Great Plain of the Koukdjuak (66°N, 73°W), where many have been banded in recent years (K. M. Dickson, personal communication), and have been seen in many other parts of Baffin Island, especially on the west side, north at least to Bernier Bay (71°N, 88°W). The Tall Grass Prairie Population, to which these birds belong, defies enumeration at any stage of its annual life cycle. It migrates through central North America to winter in south-west Texas and north-east Mexico, passing though staging areas used by many other populations, so that it is hard to tell how its numbers may be changing. *B. hutchinsii* was first found breeding in west Greenland in 1914, but has since done so irregularly and in small numbers (Salomonsen 1967). It seems to have been greatly outnumbered there by *B. c. interior* during the latter's recent expansion (Boertmann 1994). Whether *B. hutchinsii* and *B. c. interior* can share the same breeding areas is not clear.

The distribution and abundance of various waterbirds in Nunavut are changing. Inuit hunters are providing important observations on these changes that have subsequently been confirmed by scientific surveys (e.g., Robertson and Gilchrist 1998; Mallory et al. 2003). While much of our evidence is presently circumstantial, the observations and oral reports documented here lay the baseline for directed surveys to confirm distributional extensions. Continued efforts on gathering local ecological knowledge as well as scientific surveys need to be continued and expanded if these changes are not only to be detected but explained.

Acknowledgements

Field studies presented here received financial and logistic support from Environment Canada, the Nunavut Wildlife Management Board, and the Polar Continental Shelf Project. Thanks to the Resource Officers in each of the communities for verifying information, D. Caswell, T. Gaston, D. Haché, G. Henry, D. Heyland, D. Luukkonnen, C. Machtans, R. Malecki, and A. Reed for providing unpublished data, and K. Dickson, A. Erskine and an anonymous referee for comments on the manuscript.

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Received 14 December 2004
Accepted 15 September 2005

A Survey for Federally Listed Grassland Birds at First Nations Reserves

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Stevens, Scott D., and Troy I. Wellicome. 2005. A survey for federally listed grassland birds at First Nations Reserves, Canadian Field-Naturalist 119(4): 490-496.

We surveyed native and non-native grassland for federally listed grassland bird species at Reserves and/or Treaty Land Entitlements (TLE) belonging to five First Nations in the prairie ecozone of Canada. Ferruginous Hawk (*Buteo regalis* – of special concern), Loggerhead Shrike (*Lanius ludovicianus* – threatened), and Long-billed Curlew (*Numenius americanus* – of special concern) were observed at five of 335, three of 361, and five of 329 survey points within their respective geographic ranges. Sprague's Pipit (*Anthus spragueii*-threatened) was observed at 69 of 361 survey points and accounted for 84% of sites with listed birds. Estimates of proportions of native and non-native grassland within 400 m of survey points indicated that Sprague's Pipit preferred native grassland. Despite special effort, the Burrowing Owl (*Athene culicularia*-endangered) was not observed, although a nest from a previous year was encountered. We recorded the greatest number of species and individuals on reserves located in mixed and moist-mixed grasslands that contained large portions of native grassland. In many instances, field assessments revealed unsuitable habitat at sites that remote-sensing data classified as suitable.

Key Words: Burrowing Owl, *Athene cunicularia*, Ferruginous Hawk, *Buteo regalis*, Loggerhead Shrike, *Lanius ludovicianus*, Long-billed Curlew, *Numenius americanus*, Sprague's Pipit, *Anthus spragueii*, grassland species at risk, habitat assessment, remote sensing, Canada.

The Canadian prairies are home to more federally listed birds than any other region of Canada (COSEWIC 2003*). With the coming into force of The Species at Risk Act (SARA) in 2004, the demand for knowledge of locations of species at risk increased in Canada, particularly on federal lands. Inventories for listed bird species have been conducted in National Parks (e.g., Wynn and Jensen 1998*), National Wildlife Areas (e.g., Haber 1995*), and on Department of National Defence lands (e.g., Banasch and Barry 1998*; Dale et al. *in press*). More recently, surveys have been undertaken on Agriculture and Agri-foods Canada lands (e.g., G. L. Holroyd, personal communication). However, we are aware of no surveys for listed species on First Nations Reserves, even though Reserves are included as federal lands in the context of SARA.

Our objective was to survey Reserves and Treaty Land Entitlements (TLE) for grassland bird species listed as endangered (Burrowing Owl, *Athene cunicularia*), threatened (Loggerhead Shrike, *Lanius ludovicianus*; Sprague's Pipit, *Anthus spragueii*) or of special concern (Ferruginous Hawk, *Buteo regalis*; Long-billed Curlew, *Numenius americanus*). Ideally, such surveys should be conducted during the months of May and June, when these birds are breeding and most conspicuous (see Discussion). However, because of delays in securing permission for surveys, four of our surveys occurred between late-June until mid-July and one could not be conducted until mid-August. Nevertheless, through point counts and habitat description, we were able to gain a first indication of the relative importance of these Reserves to listed grassland birds. We were granted permission by five First Nations to conduct surveys on their lands within the prairie ecozone (Figure 1). In Alberta, we surveyed the Blood (#148) and Siksika (#146) Reserves. In Saskatchewan, we surveyed Nekaneet Cree TLE, Piapot Cree First Nation Reserve (#75) and TLE, and Assiniboine (Carry the Kettle Nakota Band) Reserve (#76). Here we present counts of listed birds observed at each of these Reserves or TLE. We also summarize visual estimates of habitat proportions at point-count locations, and summarize habitat at the landscape level with remote sensing data. Lastly, we use habitat data, current species ranges, knowledge of species biology, and timing of the surveys to interpret presence/absence of listed species and to infer the relative importance of these lands to conservation of grassland bird species at risk.

Methods

Habitat Assessment with Remote Sensing

Classified land-cover information was obtained for Alberta and Saskatchewan from the Prairie Farm Rehabilitation Administration's (PFRA) land cover (Ashton 2001*). We examined the following land-cover categories: grassland (includes both native and non-native grassland), cultivated, treed, shrub-covered, and wetland. We used ArcView 3.2® to summarize land-cover types within the boundaries of each reserve.

Surveys

Each survey was conducted some time between 25 June and 14 August 2003 (Table 1) by at least two of five observers. All observers were trained, by Canadian

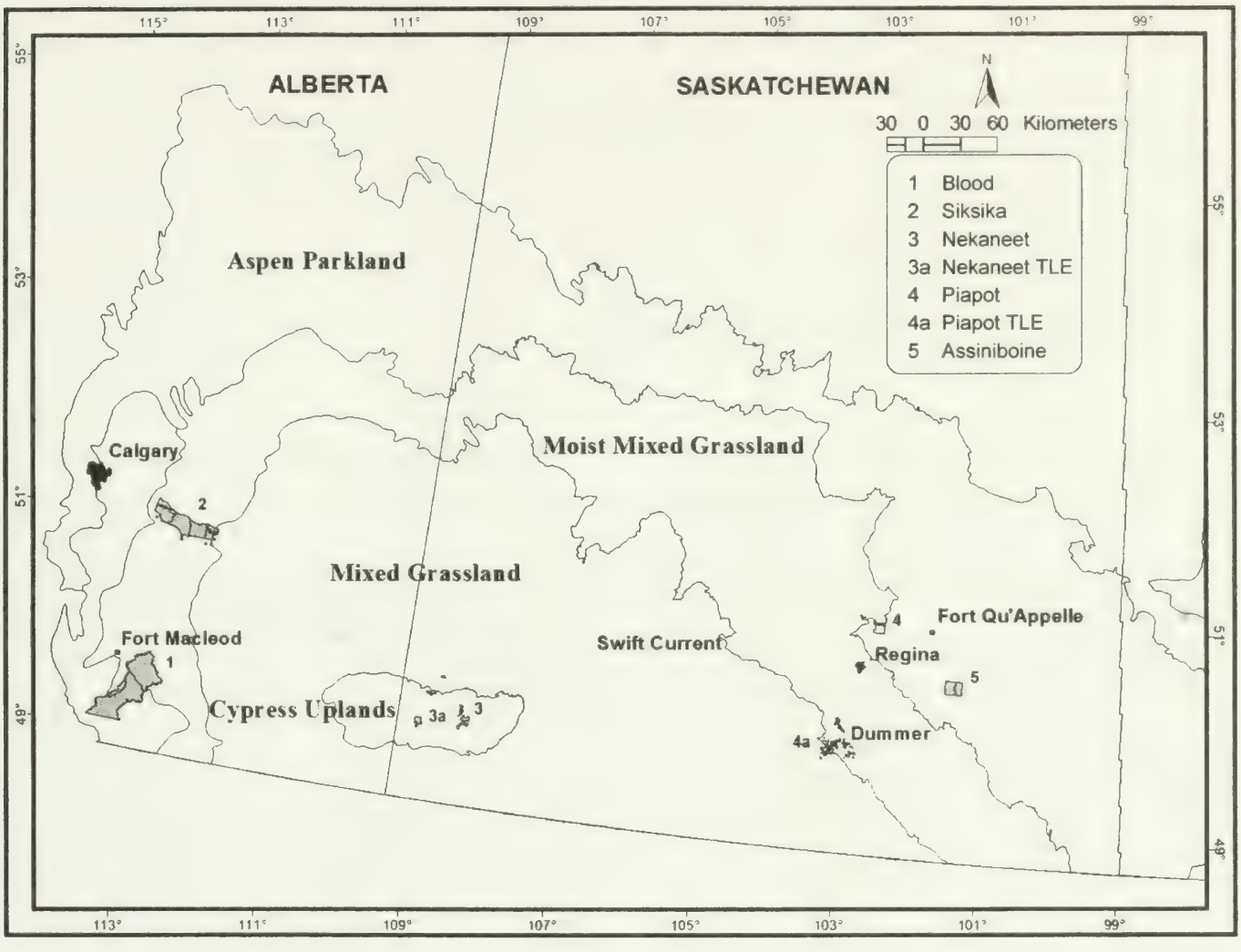

FIGURE 1. First Nations Reserves and Treaty Land Entitlements (TLE) that were surveyed for federally listed grassland birds in this study. First Nations lands are shown in relation to provincial borders, ecoregional boundaries, and nearest cities or towns.

Wildlife Service staff, in the visual and auditory identification of the target species and those non-target species that had the most potential to be confused with target species. All of the Reserves and TLE contain areas of cultivated land and treed habitat. These habitat types were not surveyed because they are generally unsuitable for the target species (Table 2). Areas were selected for point-count surveys only if surrounding land-cover was predominantly grassland (native or non-native). All suitable tracts of grassland were then covered by survey point locations that were separated at 800 m intervals in each cardinal direction to form a uniform grid. We accessed point-count stations by truck or ATV (All-Terrain Vehicle). At each point, UTM coordinates were recorded from a hand-held Garmin® GPS 12 XL. An individual observer conducted a three-minute passive scan, using binoculars to identify and record all target species. Due to the relative rarity of the Burrowing Owl, we also used a portable CD player (Citizen® JCD4109) to broadcast recorded breeding calls of a male Burrowing Owl while scanning for an additional three minutes. Sprague's Pipit were identified by their territorial songs during the passive phase of the scan and all other species by direct observation with binoculars. After completion of the six-minute scan, we estimated percent cover of several habitat types within a 400-m (50.2 ha) radius: native grassland, non-native grassland, cultivated land, trees, shrubs, and wetlands. This habitat assessment was performed to estimate habitat composition, at the same scale as the bird counts, using the same variables identified in the PFRA database. Habitat assessment in the field also enabled us to distinguish native from non-native grassland.

Results

Potential Listed Bird Species and Habitat Characteristics at Reserves

The Blood Reserve, surveyed 12-14 August, is at the western edge of the ranges of all five listed species: Burrowing Owl (Wellicome and Holroyd 2001), Loggerhead Shrike (Yosef 1996), Sprague's Pipit (Robbins and Dale 1999), Ferruginous Hawk (Bechard and Schmutz 1995), and Long-billed Curlew (Dugger and Dugger 2002). The Blood was the largest reserve in this study (Table 2), with 40% of overall land-cover classified as grassland and most of the remaining land classified as cultivated (Table 2). Remote sensing

TABLE 1. Summary of listed grassland birds at First Nations Reserves and Treaty Land Entitlements (TLE) during 2003 point-count surveys. BUOW = Burrowing Owl; FEHA = Ferruginous Hawk; LBCU = Long-billed Curlew; LOSH = Loggerhead Shrike; SPPI = Sprague's Pipit. Numbers for each species denote survey points at which they were detected. In parentheses is the total number of individuals detected.

Reserve	Ecoregion listed species	Potential # Survey	Date of Points	# Survey	BUOW	FEHA	LBCU	LOSH	SPPI
Blood	Moist-mixed Grassland	5	12-14 August	96	0	1	1	0	1
Siksika	Moist-mixed Grassland	5	25-27 June	148	0*	2	4 (6)	3	44 (52)
Nekaneet TLE	Mixed Grassland	5	9-11 July	85	0	2	0	0	21 (27)
Piapot TLE	Moist-mixed Grassland	4	7-8 July	6	0	0	—	0	2
Piapot	Aspen Parkland	2	7-8 July	15	—	—	—	0	1
Assiniboine	Aspen Parkland	2	3-4 July	11	—	—	—	0	0
Total				361	0	5	5 (7)	3	69 (83)

*One inactive Burrowing Owl nest site, which appeared to have been occupied in previous years, was noted at the Siksika reserve.

TABLE 2. Total hectares and %cover of habitat types at First Nations Reserves and Treaty Land Entitlements (TLE) based on remote sensing. In parentheses, total number of hectares surveyed at each reserve and summary of habitat percentages within a 400-m radius of survey-points. Percentages of habitat types at survey-points reported as mean ± standard error. For "Grassland", %Native and %Non-native was distinguished visually in the field.

Reserve	Total in ha	%Grassland (%Native)	(%Non-native)	%Cultivated	%Trees	%Shrubs%	%Wetlands
Blood	140124	40.3	58.9	0.2	0.1	<0.1	
	(4823)	(77.8 ± 2.6)	(0.8 ± 0.4)	(19.3 ± 2.5)	(0.3 ± 0.2)	(0.4 ± 0.1)	(1.5 ± 0.3)
Siksika	71339	68.1	27.1	0.9	1.5	0.0	
	(7436)	(88.8 ± 1.6)	(2.3 ± 0.9)	(5.7 ± 1.3)	(0.9 ± 0.4)	(0.7 ± 0.2)	(1.8 ± 0.2)
Nekaneet TLE	10725	95.2	2.0	0.1	1.7	0.0	
	(4271)	(69.1 ± 3.2)	(15.3 ± 2.8)	(5.2 ± 1.4)	(3.1 ± 0.9)	(6.3 ± 0.7)	(1.1 ± 0.2)
Piapot TLE	11244	2.6	91.0	0.3	1.9	3.2	
	(301)	(23.6 ± 5.5)	(34.1 ± 8.8)	(35.9 ±10.0)	(5.3 ± 4.9)	(0.5 ± 0.2)	(0.7 ± 0.3)
Piapot	8140	38.4	44.4	7.4	2.2	5.2	
	(754)	(0.3 ± 0.3)	(67.7 ±10.4)	(8.3 ± 8.3)	(23.0 ±10.6)	(0.5 ± 0.2)	(0.2 ± 0.2)
Assiniboine	16375	76.3	19.4	3.9	0.0	0.3	
	(553)	(14.0 ± 6.2)	(65.0 ±10.8)	(0 ± 0)	(15.7 ± 5.0)	(2.8 ± 1.5)	(2.7 ± 1.4)
Overall	259197	54.6 ± 11.5	40.5 ±12.9	5.4 ± 3.4	1.4 ± 0.4	1.6 ± 0.8	
	(18138)	(74.7 ± 1.6)	(9.1 ± 1.2)	(10.4 ± 1.1)	(2.2 ± 0.5)	(2.0 ± 0.3)	(1.5 ± 0.1)

attributed very little land cover to trees and shrubs. Overall land-cover estimates for trees and shrubs were similar to what we observed at survey-points (Table 2). Visual estimates at point-count locations revealed that most grassland is native.

The Siksika Reserve is also near the western edge of the ranges of all target species. We surveyed the Siksika Reserve 25-27 June (Table 1). It was the second largest of the five reserves (Table 2), with 68% of overall land-cover classified as grassland and scarce tree and shrub cover (Table 2). Visual estimates at point-count locations revealed that grasslands were almost exclusively native. Tree and shrub cover at survey-points was similar to overall land-cover estimates (Table 2).

Located northeast of Cypress Hills, the Nekaneet Cree Nation Reserve contains rolling habitat that is extensively treed and thus unsuitable for grassland species. However, Nekaneet TLE, which is separate from the reserve proper (Figure 1), is within the ranges of all of the target species and has suitable habitat. On Nekaneet TLE, remote sensing classified 95% of land-cover as grassland, with very minor shrub and cultivation coverage (Table 2). However, visual estimates from survey points revealed that as much as 15% of the grassland is non-native and that trees and shrubs are in somewhat higher proportions within the grasslands than is indicated by remote sensing.

Piapot Reserve is within the range of the Loggerhead Shrike and Sprague's Pipit and is near the eastern edge of the Burrowing Owl and Ferruginous Hawk ranges, at the transition from Moist Mixed Grassland to Aspen Parkland. The Reserve was surveyed 7-8 July (Table 1). Although remote sensing classified 38% of the Reserve as grassland, visual estimates indicated that very little native grassland remains on the Reserve, most having been converted to non-native pasture. These pastures contained a much higher

TABLE 3. Summary of habitat characteristics for points at which listed species were observed. Percentages reported as mean ± standard error. The category 'Present' includes locations where any of the five listed species was observed. "Absent" includes all locations at which listed species were not observed.

Species	*N*	%Native	%Tame	%Cultivated	%Tree	%Shrub	%Wetlands
FEHA	5	90.6 ± 3.2	0 ± 0	2.0 ± 2.0	0.4 ± 0.4	2.2 ± 2.0	4.8 ± 3.9
LBCU	5	77.4 ± 13.3	0 ± 0	21.6 ± 13.4	0 ± 0	0 ± 0	1.0 ± 0.3
LOSH	3	97.3 ± 0.9	0 ± 0	0 ± 0	1.0 ± 0.6	1.3 ± 0.7	0.3 ± 0.3
SPPI	69	87.7 ± 2.3	1.8 ± 1.0	3.5 ± 1.5	1.8 ± 1.1	4.0 ± 1.4	1.2 ± 0.2
Present	82	86.2 ± 2.4	1.6 ± 0.9	4.6 ± 1.6	1.7 ± 0.9	3.7 ± 1.0	1.4 ± 0.3
Absent	279	71.6 ± 1.9	11.2 ± 1.5	12.0 ± 1.3	2.4 ± 0.6	1.5 ± 0.3	1.5 ± 0.2

FEHA – Ferruginous Hawk; LBCU – Long-tailed Curlew; LOSH – Loggerhead Shrike; SPPI – Sprague's Pipit.

proportion of trees than is indicated by remote sensing (Table 1).

Piapot TLE, south and west of the Piapot Reserve (Figure 1), is well within Moist Mixed Grassland but east of the range of the Long-billed Curlew. Ninety-one percent of the land is cultivated, and visual estimates indicated that remaining grassland (3%) contains more non-native than native grassland. Trees and shrubs were in higher proportion within the areas surveyed than is indicated by remote sensing (Table 2).

Assiniboine Reserve is located in the Aspen Parkland, outside of the current ranges of the Burrowing Owl, Ferruginous Hawk, and Long-billed Curlew, but inside the range of both the Loggerhead Shrike and Sprague's Pipit. Remote sensing classified 76% of land cover in the Assiniboine Reserve as grassland (Table 2). Visual estimates at survey-points, however, revealed that 65% of grassland was non-native and that trees and shrubs were in higher proportions than indicated by remote sensing.

Species Observations

Listed birds were observed at 82 of the 361 (23%) survey points (Table 1). Of the 82 points with listed birds, Sprague's Pipit was observed at 69 (84%); it was relatively common at Siksika (44 of 148 points; 30%), Nekaneet TLE (21 of 85 points; 25%), and Piapot TLE (two of 6 points; 33%), but was seldom detected at the Blood (1 of 96 points; 1%) and Piapot (one of 15 points; 7%) Reserves. Ferruginous Hawks were observed at one location on the Blood Reserve and two locations on the Siksika Reserve and Nekaneet TLE, but were not detected at Piapot TLE, though this land is within their geographic range. Long-billed Curlews were most abundant at Siksika Reserve (four of 148 points; six individuals; Table 1) but were encountered only at one other location, on the Blood Reserve. Loggerhead Shrikes were observed only at Siksika (three of 148 points; 2%).

Despite special effort to locate them (i.e., taped calls), the Burrowing Owl was the only listed species not observed on any of the Reserves. However, we did find two burrows (10 m apart) at Siksika that we judged, based on several small rodent skeletal remains on and near the mounds, had previously been a Burrowing Owl nest and roost. There were no owl pellets or whitewash, and burrow entrances were beginning to collapse, indicating the site had not been used for at least one year (see California Burrowing Owl Consortium 1997).

To infer habitat selection for Sprague's Pipits, we compared visual estimates of percentage of native grassland at point locations where pipits were present versus where they were absent. We considered only Nekaneet TLE and Siksika, where the species was observed in highest abundance and where timing of surveys was concurrent with territorial songs (Robbins 1998). At both Nekaneet TLE and Siksika, the percentage of native prairie was higher at locations where Sprague's Pipits were present (Table 3). Although sample sizes were small, Ferruginous Hawks, Long-billed Curlews, and Loggerhead Shrikes showed a similar pattern (Table 3).

Discussion

The timing of these surveys most likely reduced detection rates of some target species, particularly the August survey at the Blood Reserve. Although Burrowing Owls typically begin leaving Canada on southward migration during September and October (Todd et al. 2003), males are most aggressive and conspicuous during egg laying and brood rearing (May through June) and thus more likely to respond to call playbacks during that time (Haug and Didiuk 1993; Shyry et al. 2001). Long-billed Curlews depart from northern parts of their breeding range by mid-July and from all parts of their breeding range by mid-August (Dugger and Dugger 2002). Sprague's Pipits perform persistent displays and songs from mid-April through the third week of May, with another period of elevated display from mid-June to mid-July; however, their singing ceases almost entirely by mid-August (Robbins 1998). Ferruginous Hawks (Bechard and Schmutz 1995) and Loggerhead Shrikes (Yosef 1996) do not begin migration until September, and these species may be most easily detected during breeding in May and June. Though timing for the surveys in this study was suboptimal, the relative magnitude of our counts of listed

grassland birds corresponded roughly to overall estimates of abundance for each species in Canada.

The Burrowing Owl is listed as endangered in Canada (Wellicome and Haug 1995*; COSEWIC 2003*) and has been essentially extirpated from Manitoba. The range of this species within southern Alberta and Saskatchewan is currently half the size it was 20-30 years ago (Wellicome and Holroyd 2001). Fewer than 800 pairs are estimated to remain on the Canadian Prairies (Todd 2005*), and our survey provides support for the rarity of this species. Like many areas across the Canadian prairies, the Blood and Siksika reserves, and Nekaneet TLE, appear to contain suitable but vacant Burrowing Owl habitat.

The Ferruginous Hawk, listed as a species of special concern in Canada (COSEWIC 2003*), still occupies many areas where it was reported in historical times, but has declined at the northern edge of its range in Alberta, Saskatchewan, and Manitoba (Schmutz 1995*; Schmutz et al. 1994*). The breeding population in Canada is estimated at 2000-4000 pairs (Schmutz 1995*; Schmutz et al. 1994*). Although Ferruginous Hawks prefer elevated nest sites, such as isolated trees or platforms, they occur in large tracts of open, generally arid habitats dominated by grasses or sagebrush (Bechard and Schmutz 1995). Schmutz (1989) showed that they were more abundant where levels of cultivation were low. Our results agree with these previous studies, as Ferruginous Hawks were found on reserves with the largest areas of native grassland.

Prairie populations of the Loggerhead Shrike, listed in Canada as threatened (Cadman 1985*; COSEWIC 2003*), have declined in numbers since the 1960s (Yosef 1996), and the northern limit of their range has retracted (Telfer et al. 1989). The most recent population estimate is 2500 pairs in Alberta, 7000 pairs in Saskatchewan, and 500 pairs in Manitoba (Johns et al. 1994*). All of the Reserves we surveyed were within the geographic range of Loggerhead Shrikes, but we found shrikes only at Siksika. Siksika contains sporadic shrub and tree cover, which Loggerhead Shrikes require for nesting habitat (Yosef 1996), and large areas of grassland to support prey species of Loggerhead shrikes. Although their abundance is correlated with availability of pastureland (Gawlik and Bildstein 1993), Loggerhead Shrikes occur at relatively low densities (Telfer 1993) and thus may be more difficult to detect than Long-billed Curlews, Ferruginous Hawks, and vocalizing Sprague's Pipits.

Long-billed Curlews, listed as a species of special concern in Canada (De Smet 1992*), are now considered extirpated in Manitoba (De Smet 1992*; Hill 1998*) and very rare in areas of southeastern Saskatchewan, where they were once common (Renaud 1980). Although the population in Alberta has been estimated at approximately 24 000 (assuming equal sex ratio; Saunders 2001*), it is suspected they are declining rapidly in eastern parts of their range, including Saskatchewan (De Smet 1992*; Saunders 2001*). Long-billed Curlews nest close to wetter areas in short grass or mixed-grassland habitat (Hooper and Pitt 1996*) and avoid areas with trees and high densities of shrubs (Pampush and Anthony 1993). We did not observe Long-billed Curlews at Nekaneet TLE, which is within their geographic range, perhaps because the grasslands there contain few wetlands and relatively high shrub-cover. Habitat characteristics were generally similar between Blood and Siksika Reserves, but we observed more Long-billed Curlews at Siksika. One difference that may help explain this result is the lower proportion of wetlands at the Blood Reserve. Perhaps more importantly, however, our survey at the Blood Reserve was late, so many Long-billed Curlews may have already started to migrate south.

Sprague's Pipit is listed as threatened in Canada (COSEWIC 2003*). Although still locally abundant, populations of Sprague's Pipit have been declining rapidly in parts of their range, with the greatest decline occurring in Canada's prairie provinces (Sauer et al. 1997*). Populations in Alberta and Saskatchewan, where highest densities occur, have declined by 9.4% and 5.4% per year, respectively (Prescott and Davis 1998*). Sprague's Pipits prefer native grassland, rarely being found in cultivated fields or where native grasses have been replaced by introduced species (Robbins and Dale 1999). Accordingly, the only Reserve where Sprague's Pipits were not observed in this study was the Assiniboine, which is composed predominantly of non-native grassland. The species was found in relative abundance at the Nekaneet TLE and the Siksika Reserve, which both contain substantial proportions of native grassland. The Blood Reserve, which also contains large tracts of native grassland, albeit at the western edge of the range, probably contains a larger population of Sprague's Pipit than our late survey would suggest. By mid-August male territorial vocalizations are rare (Robbins 1998) and thus Sprague's Pipit are exceedingly difficult to detect at that time.

Our comparison of percentage native grassland between those sites at Siksika and Nekaneet TLE where Sprague's Pipit were and were not detected (in surveys concurrent with male territorial songs) support other studies showing a preference for native grassland by this species (Robbins and Dale 1999). Although sample sizes were small, Ferruginous Hawks, Long-billed Curlews, and Loggerhead Shrikes were also observed at point locations with high percentages of native prairie, suggesting the importance of native grasslands to these species.

The PFRA land-cover data can be misleading for large-scale habitat assessments because they do not distinguish native from non-native grassland, and tend to underestimate shrub and tree cover within grasslands. Based on visual habitat estimates, the Assiniboine and Piapot Reserves, which are both in aspen parkland, contained high proportions of trees and tame pasture

and were of relatively little importance to listed grassland birds. In contrast, the Siksika and Blood Reserves, which are in moist-mixed grassland, and Nekaneet TLE, which is in mixed grassland, each contain relatively large proportions of native grassland and appear to be important areas for listed grassland birds.

Acknowledgments

Funding support for this project was provided by the Canadian Wildlife Service, in the Prairie and Northern Region of Environment Canada. We extend our thanks to Dave Duncan, who encouraged us to undertake these surveys, and to the Blood, Siksika, Nekaneet Cree, Piapot Cree, and Carry the Kettle First Nations for granting us access to their lands. For excellent assistance in the field, we thank Stephanie Grossman, David Junor, and Joann Skilnick. We also thank Geoffrey L. Holroyd, of the Canadian Wildlife Service, for sharing a personal communication about his species-at-risk surveys on Agriculture and Agri-foods Canada lands. Special thanks to David Junor for using the PFRA GIS dataset to calculate proportions of land-cover within each reserve and also for preparing Figure 1.

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Received 2 February 2004
Accepted 27 October 2005

Addition to the Flora of Canada? A Specimen from the Arctic Archipelago, Northwest Territories Links Two Allopatric Species of Alkali Grass, *Puccinellia*

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Consaul, L. L., L. J. Gillespie, and K. I. MacInnes. 2005. Addition to the flora of Canada? A specimen from the Arctic Archipelago, Northwest Territories links two allopatric species of alkali grass, *Puccinellia*. Canadian Field-Naturalist 119(4): 497-506.

A single herbarium specimen from Banks Island in the Canadian National Herbarium, Ottawa, is closest to *Puccinellia wrightii* (*Puccinellia* sect. *Pseudocolpodium*). This would represent a species new to Canada and an extension of over 1100 km from the previously known range in NW Alaska and NE Russia. The morphological characteristics of this specimen are compared with all taxa in *P.* section *Pseudocolpodium* and the North American *P. arctica* aggregate. Principal components analysis supports placement of this specimen in *P.* section *Pseudocolpodium* near *P. wrightii*, where it contributes to a morphological continuum between this species and *P. vahliana*. The new combination *Puccinellia wrightii* var. *flava* is made and a map of the current known distribution of the species in *P.* section *Pseudocolpodium* is presented.

Key Words: Alkali grass, *Puccinellia wrightii*, *Puccinellia* section *Pseudocolpodium*, principal components analysis, Canadian Arctic Archipelago.

Alkali grasses (*Puccinellia* Parl.) are tufted, pioneering grasses which are usually found along the seashore or on interior salt pans and alkaline marine sediments in both temperate and arctic regions. They have soft, often inrolled leaves, panicles with several florets per spikelet, small glumes that are shorter than the awnless lemmas, and lemmas with rounded backs. *Puccinellia* is currently the largest Arctic grass genus.

Puccinellia has a long history of taxonomic uncertainty and plants are often difficult to identify. Fernald and Weatherby (1916, page 1) called it "even to agrostologists, one of the most perplexing groups of grasses...," Polunin (1940, page 67) commented that: "the characters are variable... [*P. angustata*] is a most unsavoury aggregate...," and Davis (1993, page 202) called it "one of the more controversial genera in the grass family in terms of species delimitation." Whereas over 300 species have been described worldwide, 30 to 80 species have been accepted over the span of the last 20 years (Gould and Shaw 1983; Davis 1983; Watson and Dallwitz 1999*).

During examination of specimens for morphological studies on alkali grasses of the Canadian Arctic Archipelago (CAA) (Consaul and Gillespie 2001) and the grasses of the CAA (Aiken et al. 2000*), a herbarium specimen was found that did not key to any known Canadian grass species and was not discussed in either of these works. It had been collected by Kaye MacInnes during an ecological survey with John Lambert (Carleton University) of an area on Banks Island near Egg River. This area was under study because it was proposed as an International Biological Program (IBP) site. Although not designated as an IBP, the area falls within the Banks Island No 1 Migratory Bird Sanctuary, which protects the nesting habitat of the Lesser Snow Goose, *Chen caerulescens caerulescens*. Knowledge of baseline botanical information in this area, especially from specimens in the 1970s, is of interest because Snow Goose colonies have increased dramatically in recent years (McRae et al. 1994). At the Banks Island sanctuary the geese are now foraging further inland and upland than their original grounds in the valley of the Big River (Jim Hines, Natural Resources Canada, personal communication, 2003). While geese feed commonly on *P. phryganodes*, a stoloniferous species that grows in low saline environments in the area, the *Puccinellia* specimen in question was growing on upland slopes where the geese have been spreading.

Puccinellia in the North American Arctic may be placed into three sections of the classification by Tzvelev (1976). *Puccinellia* section *Paralochloa* contains the stoloniferous species *P. phryganodes* (Trin.) Scribn. & Merr. *Puccinellia* section *Puccinellia*, containing most species in the CAA, has glumes that are relatively uneven in size, with the first glume being less than ½ the length of the first lemma, and usually short anthers. The *P. arctica* aggregate with long anthers, first recognized by Polunin (1959) and endemic to North America, likely belongs in this section but has not been formally placed here because the sectional classification was established for species in

* See Documents Cited section

Russia. *Puccinellia* section *Pseudocolpodium* has glumes that are relatively even in size, with the first glume usually over ½ the length of the first lemma, fairly long anthers, and thick, crinkled roots. Worldwide, six species have been described in this section: *P. beringensis* Tzvelev, *P. byrrangensis* Tzvelev, *P. colpodioides* Tzvelev, *P. jenisseiensis* (Roshev.) Tzvelev, *P. vahliana* (Liebm.) Scribn. and Merr., and *P. wrightii* (Scribn. & Merr.) Tzvelev. The last two species, of which the latter is represented by two varieties (see under Taxonomy below), were originally described in the genus *Colpodium. Puccinellia vahliana* is the only Canadian species; *P. wrightii* is from Alaska and Russia and is the next closest geographically; and the other species are from Russia.

Previous determinations by S. G. Aiken (Canadian Museum of Nature) had placed the Banks Island specimen in *Puccinellia arctica* (Hooker) Fernald and Weath. (in 1989), and later in *P. agrostidea* T. J. Sørensen (in 1994) of the *P. arctica* aggregate owing to its long anthers and fairly uneven glumes. In early principal components analyses for the morphological study of *Puccinellia* by Consaul and Gillespie (2001), this specimen did not associate with any groups. Upon reexamination of the specimen, LLC identified it (in 2000) as "*P. vahliana* × ?" of section *Pseudocolpodium* because it had relatively long glumes and thick, crinkled roots.

This paper presents the findings of our investigation into the identity of this specimen. The specific objectives are (1) to confirm whether this taxon belongs to the large-anthered *P. arctica* aggregate, or to *P.* section *Pseudocolpodium*, and (2) to determine whether it aligns with a currently described species in the genus.

Methods

A single specimen from the National Herbarium of Canada (N.W.T., Banks Island, Egg River, Area #16, *K. L. MacInnes s.n.*, 24 July 1971, CAN 535850) is the subject of this study [collection acronyms follow Holmgren et al. 1990]. We consulted floras of Canada, Alaska, and Russia to determine the putative identification of the specimen. After preliminary screening the specimen was considered to be most closely related to species in *Puccinellia* section *Pseudocolpodium* or to members of the North American *P. arctica* aggregate (*P. agrostidea*, *P. arctica,* and *P. poacea*). We compared the morphological characteristics of the CAN 535580 specimen with specimens of these species.

For *P. agrostidea* (including holotype), *P. arctica*, *P. poacea* (including holotype), and *P. vahliana*, many specimens were initially examined to determine the range of variation, and a set of ten to 12 specimens of each (Appendix 1) were scored (Table 1). *Puccinellia agrostidea* was excluded from Table 1 because of the uncertainty of its taxonomic limits, as well as its relatively small florets and anthers. Eight specimens of *P. wrighti* var. *wrightii*, including the holotype, were obtained and examined. Material was scant or lacking for the other taxa. Only three specimens of *P. colpodioides* were available, and the holotype of *P.wrightii* var. *flava* (the only collection known to date) was included. Measurements were made on five separate culms of both the CAN 535850 and the *P. wrightii* var. *flava* (Scribn. & Merr.) Consaul (see Taxonomy section below) collections, and each culm was considered as a separate Operational Taxonomic Unit (OTU), because we had only a single herbarium sheet of each. Data from original descriptions of *P. beringensis*, *P. byrrangensis*, and *P. jenesseiensis* were used for comparison since no specimens were available. Of these, only *P. byrrangensis* was included in the final dataset, since initial examination showed that CAN 535850 keyed out close to this species but not to the other two.

The characters examined were the same as those found useful in separating *Puccinellia* taxa in the analyses of Consaul and Gillespie (2001: Tables 2 and 4). Two additional qualitative characters, "presence or absence of hyaline margin" and "inflorescence open or contracted," were added since they had been used in keys to these species. For *P. wrightii* and *P. colpodioides*, we kept the data of the non-type herbarium specimens separate from the data of the protologue and the holotype. For *P. byrrangensis* only data from descriptions was used.

A principal components analysis (PCA) was performed using SYSTAT 7.0 on all taxa for which we had specimens, except one. *Puccinellia wrightii* var. *flava* was excluded because its very large spikelet measurements make it clearly different from CAN 535850. A subset of five representative specimens of most taxa, the three of *P. colpodioides,* and the five culms of CAN 535850 were used for the PCA to balance the ordination because of the low number of specimens of some species available for analysis. We recognized that the dispersion of data points in any ordination analyses we performed on these measurements for the single collection of CAN 535850 (likely representing a single plant) might be narrower than the dispersion when each OTU was from a separate population.

The PCA was performed on the quantitative characters listed in Table 1, plus height, ligule length, length of first internode of panicle, palea length, callus hair length, extent of hair from base of lemma, and extent of hair from apex of palea (characters from Consaul and Gillespie 2001). A dataset reduction procedure used by Davis (1983) and established as useful in Consaul and Gillespie (2001) was used here. In this procedure, a group of OTUs which separated from the rest of the data was removed before the remaining reduced dataset was analyzed in a subsequent PCA. In this way, the PCA would calculate the axes on the variation present in the remaining smaller group, thus potentially revealing further groupings among the smaller set of OTUs.

TABLE 1. Characters compared for CAN 535850, specimens in *Puccinellia* section *Pseudocolpodium*, and specimens in the *Puccinellia arctica* aggregate. States of CAN 535850 and states of other taxa that overlap with it are in bold. When the specimen data was kept separate from protologue and type data, the former is in square brackets [ ]. An asterisk (*) indicates data could not be determined. The number of similarities of each taxon with CAN 535850 is totalled in the column "Sim."

Taxon	Inflor. branches open (o) or contracted (c)	Trichomes on margins of glumes and lemmas	1st glume length (mm)	2nd glume length (mm)	Lemma length (mm)	Ratio 1st glume: lemma length	Ratio anther: lemma length	Lemma hair villous	Hyaline margin narrow (n)/mod (m)/wide (w)/very wider(vw)
Code in C & G (2001, Table 1)	none	FGLAPC LEMAPC	FGLL	SGLL	LEML	RGLLEM	RANTLEM	LEMH	
P. Egg River CAN 535850	**o at base**	**no**	**2.1-2.2**	**2.9-3.2**	**3.5-4.0**	**0.55-0.62**	**0.40-0.46**	**yes (occ. no)**	**m to vw**
P. vahliana. Specimens	c	**no**	**2-3.4**	**2.4-4**	**3.2-5.2**	**0.58-0.81**	**0.24-0.43**	**yes**	**n to w**
P. wrightii Protologue and Holotype	**o**	**no**	**1.5-2.5 (-3.1)**	**2.5-3.5 (-3.9)**	4.5-5.0	*	**0.38-0.50**	**yes**	**m**
[Specimens]	**[o & c]**	**[no]**	**[2.2-3.5]**	**[2.9-3.8]**	**[4.0-5.0]**	**[0.41-0.57]**	**[0.41-0.51]**	**[yes]**	**[m]**
P. wrightii var *flava* Protologue and Holotype	**o**	**no**	3.3-4.6	4.2-5.1	5.2-6.0	**0.60-0.77**	**0.40-0.50**	no	**m**
P. colpodioides Protologue	+/- c	**no**	1.8	2.5	**3.0-4.0**	*	*	**yes**	**w**
[Specimens]	**[o & c]**	**[no]**	**[1.9-2.8]**	**[2.5-3.4]**	**[3.7-4.2]**	**[0.55-0.65]**	**[0.45-0.56]**	**[yes]**	**[m]**
P. byrrangensis Protologue	c	**no**	**1.5-3**	**1.5-3**	**2.7-4.0**	*	*	no	**vw**
P. arctica Specimens	c	yes	1-1.2	1.9-2.2	2.8-3.2	0.33-0.42	0.47-0.71	**slight**	n
P. poacea Specimens including Holotype	**o when mature**	yes	1.2-1.6	1.9-2.8	2.1-3.0	**0.32-0.55**	0.47-0.80	**slight**	n

Taxon	Ratio infl. length/ plant height	Infl. primary branch length (cm)	Max. divergence of infl. branches	# infl. branches at lowest node	1st glume width (mm)	2nd glume width (mm)	Ratio 1st glume: 2nd glume length	Anther length (mm)	Lemma longitud. ridges	Palea hair glabrous (g)/ scabrous(s)/ villous(v)	SIM
Code in C & G (2001, Table 1)	RINHT	PRBRL	BRDIV	INBRNU	FGLW	SGLW	RGLLEN	ANTL	LEMV	PALH	
P. Egg River CAN 535850	**0.17-2.7**	**1.4-2.7**	**ascending or horizontal**	**(2-) 4-5**	**0.6-0.8**	**0.7-1.0**	**0.68-0.83**	**1.6-1.8**	**yes**	**s**	
P. vahliana, Specimens (CAN)	0.32-5	**1.2-1.8**	**erect or ascending**	2-3	1.0-1.4	**1.0-1.6**	**0.78-1.0**	**1.0-1.6**	**occas.**	v	**-** **14**
P. wrightii Protologue and and Holotype [Specimens]	0.16 [0.12 -0.13]	3.7 **[2.5-4.0]**	**ascending or horizontal**	usu in pairs **[2-6]**	**[0.6-1.0]**	**[0.8-1.3]**	**0.69-0.90** **[0.62-0.78]**	**1.5-2.5** [2-2.1]	**yes** **[yes]**	**s** [s/v]	**18**
P. wrightii var. *flava* Protologue and Holotype	0.36-0.40	3.6-4.2	**horizontal**	1-3	**0.8-1.2**	1.1-1.2	**0.66-0.90**	2.2-2.5	no	**s**	**7**
P. colpodioides Protologue [Specimens]	* [0.26-0.35]	* **[1.3-2.6]**	* **ascending**	1-2 [2-3]	[0.9-1.1]	**[0.9-1.3]**	* **[0.78-0.93]**	**1.5-2.5** **[1.6-2.3]**	obscure [no to faint]	**+/-** v [v]	**14**
P. byrrangensis Protologue & text	*	*	*	*	*	*	*	**1.3-1.7**	**yes**	**~g**	**—**
P. arctica Specimens (CAN)	**0.20-0.30**	**2-3.8**	**erect or ascending**	**3-7**	**0.6-0.7**	**0.7-1.0**	**0.48-0.76**	**1.6-2.1**	no	**s**	**10**
P. poacea Specimens including Holotype (CAN)	**0.22-0.33**	**1.9-4**	**ascending**	**3-6**	**0.5-0.8**	**0.6-1.2**	**0.32-0.76**	**1.3-1.9**	no	**s**	**12**

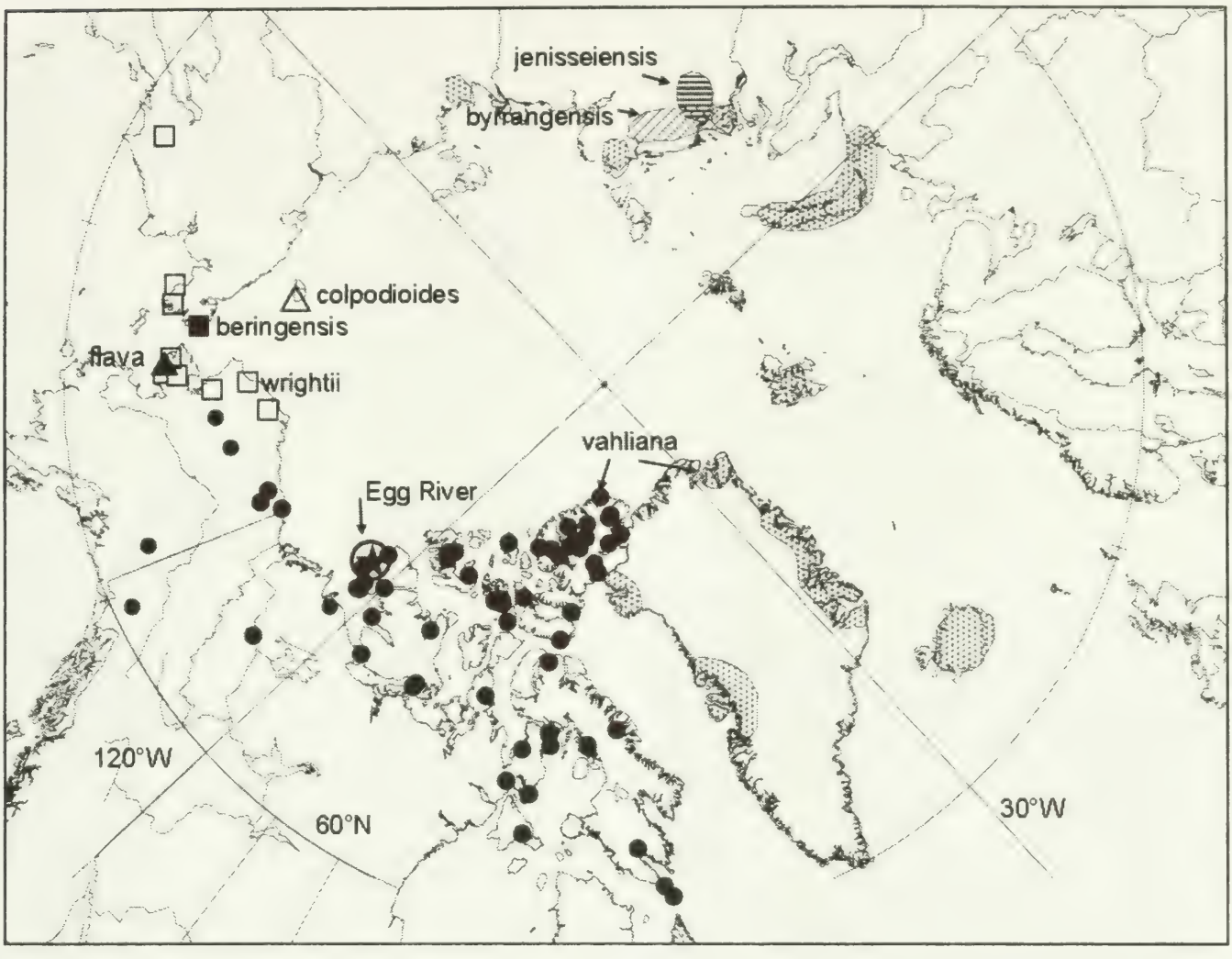

FIGURE 1. Map of species in *Puccinellia* section *Pseudocolpodium*. Star in circle = CAN 535850. Solid circles and dot patterns = *P. vahliana*; open squares = *P. wrightii*; solid square = *P. beringensis*, representing several localities; open triangle = *P. colpodioides*; diagonal hatching = *P. byrrangensis*; horizontal hatching = *P. jenisseiensis*; solid triangle = *P. wrightii* var. *flava*.

The current distribution of the species in *P.* section *Pseudocolpodium* was mapped (see Figure 1). The distribution of *P. vahliana* is based on specimens from CAN and DAO (solid circles), as well as the maps in Hultén (1968) (area indicated by dot pattern) and Cody (1996) (Yukon record). The open squares representing *P. wrightii* var. *wrightii* are based on specimens from CAN, DAO, ALA and US, as well as the dot map in Probatova (1985) and text in Tzvelev (1964). The open triangle of *P. colpodioides* is based on several specimens from CAN and ALA, and text in Tzvelev (1964). The solid triangle representing *P. wrightii* var. *flava* is from the holotype, the only specimen known. The distribution of *P. beringensis* (closed square) is based on the dot map in Probatova (1985), *P. byrrangensis* (diagonal hatching) is based on the dot map in Malyshev and Peshkova (1990), and *P. jenisseiensis* (horizontal hatching) is based on a description of the distribution in Tzvelev (1964).

Results

A morphological and habitat description of CAN 535850 is given in Appendix 2. Figure 1 shows the distribution of CAN 535850, labelled "Egg River," compared with all the taxa in *Puccinellia* sect. *Pseudocolpodium*.

Using *Anderson's Flora of Alaska and Adjacent Parts of Canada* (Welsh 1974), CAN 535850 keyed out to *Puccinellia wrightii* (as *Colpodium wrightii* Scribn. & Merr.). In *Grasses of the Soviet Union* (Tzvelev 1976), it keyed out intermediate between *P. colpodioides* (as *P. wrightii* subsp. *colpodioides* (Tzvelev) Tzvelev) and *P. byrrangensis*.

Single characters

Table 1 presents a morphological comparison of the *Puccinellia* taxa under study. The values of CAN 535850 and the values that overlap with those of CAN 535850 are highlighted in bold. Figure 2 shows photographs of inflorescences and spikelets comparing CAN 535850 with the other closely related species.

CAN 535850 had 14-18 similarities with taxa in *P.* section *Pseudocolpodium* (except for *P. wrightii* var. *flava*) and 10-12 similarities to taxa in the *P. arctica* aggregate (Table 1, column SIM). The first nine characters in Table 1 show the overlap between CAN

535850 and species in *P.* section *Pseudocolpodium* that are different, for the most part, than the values in the *P. arctica* aggregate. One character in Table 1, ratio of inflorescence length to plant height, showed no overlap of CAN 535850 with any members of the *P.* section *Pseudocolpodium*, but instead showed overlap with members of the *P. arctica* aggregate.

Within *P.* sect. *Pseudocolpodium*, the taxon with the most similarities to CAN 535850 was *P. wrightii* var. *wrightii*, overlapping in 18 characters (Table 1). The next closest were *P. colpodioides* (14) and *P. vahliana* (14). The characters that were similar to *P. wrightii* var. *wrightii*, but not to *P. colpodioides* or *P. vahliana*, are number of branches at lowest node of inflorescence, first glume width, and palea hair.

Inflorescences of CAN 535850 (Figure 2a), *P. wrightii* (Figure 2c), and *P. poacea* (Figure 2e) were typically open, except when young and then closed and contracted. The inflorescence of *P. vahliana* (Figure 2b) was typically contracted, although sometimes slightly more loosely than in the photograph. The inflorescence of *P. colpodioides* (Figure 2d) was variable in shape, most often being contracted as in *P. vahliana*, but sometimes slightly more open as in Figure 2d and more closely resembling CAN 535850.

Multivariate analysis

The PCA (Figure 3a) shows that on Factor 1 (influenced by lemma, palea, and glume lengths, and extent of hair on paleas and lemmas) and Factor 2 (influenced by first glume width and anther length) species in *P.* section *Pseudocolpodium* separate from the *P. arctica* aggregate, and CAN 535850 groups in the centre of *P.* section *Pseudocolpodium*. When the *P. arctica* aggregate was removed (Figure 3b), CAN 535850 OTUs grouped between *P. colpodioides* and *P. wrightii* on Factor 1, which was most influenced by measurements of the inflorescence shape, and clusters more with *P. wrightii* on Factor 2, which is more influenced highly negatively by the first and second glume widths and callus hair length, and highly positively by the number of branches at the lowest node. The OTUs representing the single collection from CAN 535850 were dispersed almost as much as the separate collections from each of the other taxa.

Discussion

Sectional alignment

The specimen CAN 535850 aligns with *Puccinellia* sect. *Pseudocolpodium* based on the results from Table 1 and the ordinations in Figure 3. The specimen CAN 535850 and all of the species in *P.* sect. *Pseudocolpodium* have generally glabrous glume and lemma margins, whereas those in the *P. arctica* aggregate (*P. poacea* shown in Figure 2) are minutely scabrous. In addition, CAN 535850 and most of *P.* section *Pseudocolpodium* differ from the *P. arctica* aggregate by having generally longer glumes and longer lemmas with a wider hyaline margin.

Puccinellia section *Pseudocolpodium:* species alignment

The only taxon from this section recorded to date from Canada is *P. vahliana*. CAN 535850 differs from *P. vahliana* by having diverging inflorescence branches, a smaller inflorescence to height ratio, narrower glumes, and by lacking thick villous hair at the base of the palea. CAN 535850 also has longer primary inflorescence branches, larger anthers, and a larger ratio of anther to lemma, but there is some overlap in these three characters. The wide glumes of *P. vahliana* account for a "wrapping" effect of the glumes around the lower lemmas, especially visible when the spikelets are closed (see also *P. colpodioides* below). CAN 535850 is similar to *P. vahliana* in glume and lemma lengths (and ratios) and lemma hair characters.

The next closest taxon geographically, *P. wrightii* var. *wrightii,* is from Alaska and easternmost Russia. In comparison with *P. wrightii*, CAN 535850 differs by being shorter, having smaller ligules and shorter lemmas and paleas. They share, however, similar inflorescence branch divergence, length and width of glumes, hyaline lemma margins, longitudinal folds of the lemmas, long anthers, and hairiness of florets. The specimen CAN 535850 generally has four or five branches at the lowest node of the inflorescence. While the original description of *P. wrightii* indicated the lowermost branches in pairs, specimens from Alaska had up to six branches at the lowest node. The CAN 535850 specimen appears to be similar to *P. wrightii*, but less robust overall. This may be a consequence of our plant having grown in a more extreme environment.

The description of *P. wrightii* var. *flava* is based on only one collection from Port Clarence, Alaska. This variety was originally described as only differing from the typical variety by having yellow florets. In addition to this difference, we found that the lengths of first glume, second glume and lemmas are much larger than those of *P. wrightii* var. *wrightii*, with no overlap. The ratios of these values, however, are similar to the rest of *P.* sect. *Pseudocolpodium*. These very large length values account for the low number of similarities with CAN 535850. Moreover, CAN 535850 has straw-coloured to greenish-red florets with a bronze tinge, as opposed to yellow florets.

The remaining taxa in this subgenus are known only from Russia. CAN 535850 keys out intermediate to *P. colpodioides* and *P. byrrangensis* in Tzvelev's treatment (1976). *Puccinellia colpodioides* is a smaller plant than *P. wrightii*, and the lemma length of CAN 535850 overlaps more with the smaller lemma of *P. colpodioides* than with that of *P. wrightii*. Some of the inflorescence characters (primary branch length, maximum divergence of inflorescence branches) of CAN 535850 are similar to those of *P. colpodioides*, but the former differs by having a smaller ratio of inflorescence to plant height, a generally open inflorescence, with 4-5 branches at the lowest node, narrow glumes,

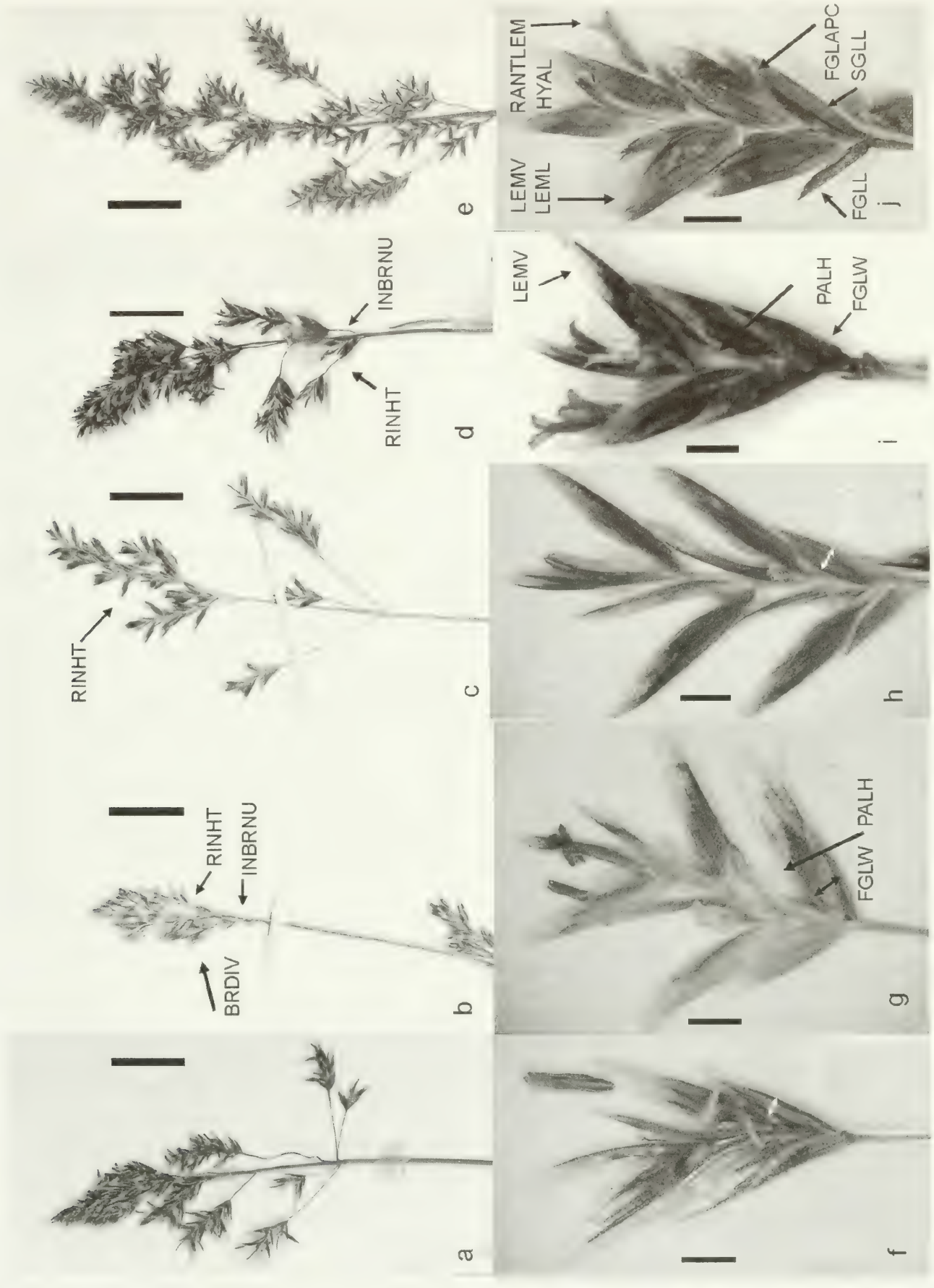

FIGURE 2. Photographs of five species in *Puccinellia* section *Pseudocolpodium* taken under a stereomicroscope. (a–e) Inflorescences, scale bar length = 1 cm. (a) CAN 535850, (b) *Puccinellia vahliana*, (c) *P. wrightii*, (d) *P. colpodioides*, (e) *P. poacea*. (f–j) Spikelets, scale bar length = 1 mm. (f) CAN 535850, (g) *Puccinellia vahliana*, (h) *P. wrightii*, (i) *P. colpodioides*, (j) *P. poacea*. Black and white arrows show features that differ from those of CAN 535850. Abbreviations for the character codes are given in Table 1.

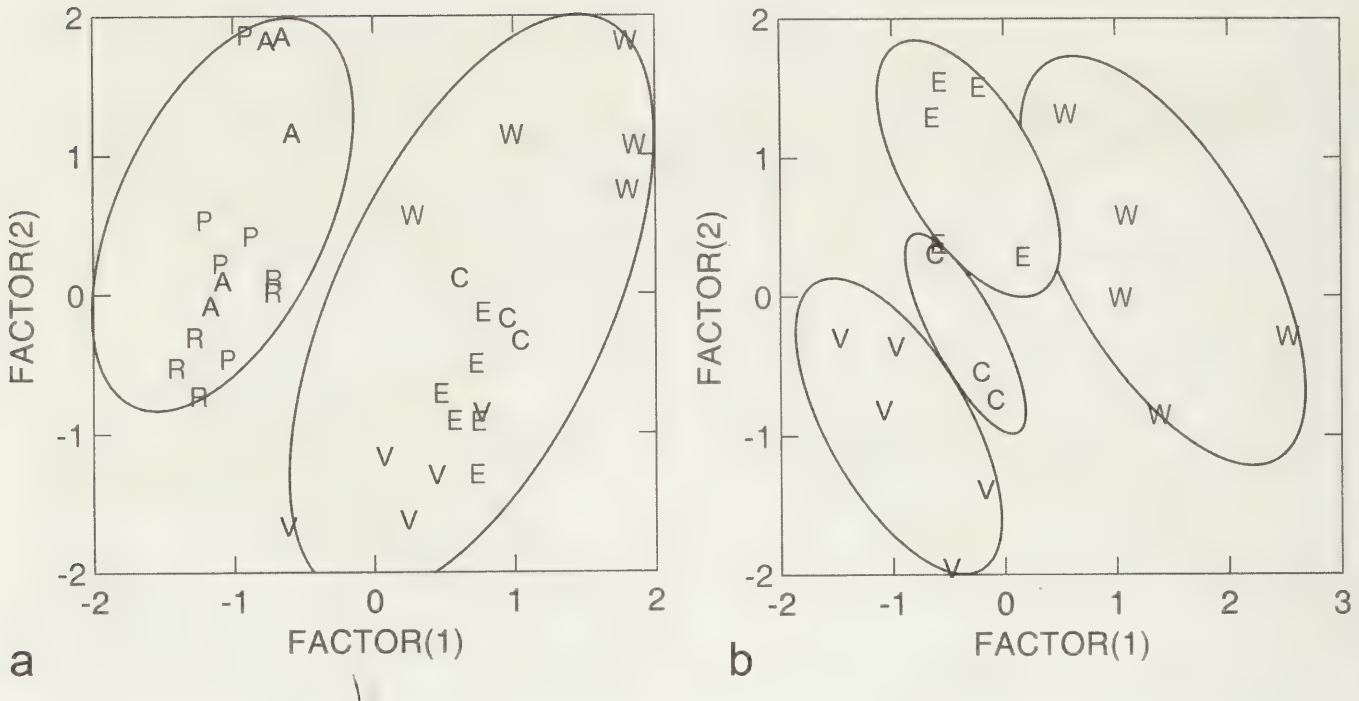

FIGURE 3. Principal components analysis. (a) Analysis on full dataset (b) Analysis on dataset without *P. arctica* aggregate. Section *Pseudocolpodium*: E = CAN 535850, V = *P. vahliana*, C = *P. colpodioides*, W = *P. wrightii*; Species of *P. arctica* aggregate, section unassigned: A = *P. arctica*, P. = *P. poacea*, R = *P. agrostidea.*

and silky hairs on the palea keels rather than villous hairs on the lower palea keels, similar points of difference to *P. vahliana*. Thus, although the specimen does resemble *P. colpodioides* superficially, close examination of the spikelets suggests that CAN 535850 is not as closely aligned to *P. colpodioides* as to *P. wrightii*. Moreover, *P. colpodioides* has wide glumes similar to those of *P. vahliana*, which makes these two species closer in appearance to each other than to CAN 535850.

Both CAN 535850 and *P. byrrangensis* have very wide hyaline margins, but this is a rather variable character in CAN 535850. These species also share obvious folds on the lemma. On the other hand, the panicle was described as contracted for *P. byrrangensis*, unlike CAN 535850 which is most often open. The palea keels are glabrous or at most very slightly pilose in P. *byrrangensis*, unlike those of CAN 535850 which are slightly scabrous distally. Thus, differences in inflorescence characters indicate that CAN 535850 is unlikely to be *P. byrrangensis,* a species endemic to the Taimyr, west Siberia and considered by Tzvelev (1964) to be intermediate between *P. vahliana* and *P. colpodioides*.

The distribution gap between CAN 535850 and both *P. beringensis* and *P. jenesseinsis* make it unlikely that the former belongs to either of these species. *Puccinellia beringensis* is reported to have paleas that are glabrous and smooth or with solitary spinules, and anthers 1-1.4 mm long (Tzvelev 1976). In contrast, CAN 535850 has paleas that are slightly scabrous and anthers 1.6-1.8 mm long. Moreover, Probatova (1985) did not even classify *P. beringensis* in section *Pseudocolpodium* [although Tzvelev (1976) did], but instead placed it in section *Puccinellia*. *Puccinellia jenesseinsis* has paleas that are glabrous or with only a few hairs basally, and inflorescences that are lax and broadly diffuse (Tzvelev 1964, 1976). Tzvelev (1964) described the lemmas as definitely lacking longitudinal folds, whereas in 1976 he said the lemmas were often longitudinally folded when dry. CAN 535850 has slightly scabrous veins to the palea as well as a few basal hairs, inflorescences that are open at the base only, and strong longitudinal folds.

From the above comparisons, CAN 535850 aligns most closely with typical *P. wrightii*, although the florets were smaller overall, which may explain why it keyed out closer to the smaller taxon *P. colpodioides*. In summary, CAN 535850 had palea hair characters resembling *P. wrightii*, glume length similar to *P. wrightii*, lemma size characteristics of *P. byrrangensis*, *P. colpodioides*, and *P. vahliana*, and the hyaline margins and longitudinal folds of *P. wrightii* and *P. byrrangensis*. Although intermediate, it is unlikely a hybrid because it is allopatric from all taxa except *P. vahliana*.

Although CAN 535850 is different from all of the other species of *Puccinellia* section *Pseudocolpodium* we do not choose to base the description of a putative new taxon on a single specimen. The species in section *Pseudocolpodium* are very similar morphologically and in our PCA form a continuum as was found for other *Puccinellia* species complexes in Consaul and Gillespie (2001). CAN 535850 falls with *P. colpodi-*

oides between *P. vahliana* and *P. wrightii* in morphological characteristics. It conservatively aligns closest to *P. wrightii,* to which it conforms to a small specimen, as much as to *P. wrightii* var. *flava* is larger. *Puccinellia wrightii* may be an aggregate species complex which includes the larger *P. wrightii* forms and the smaller forms such as *P. colpodioides* and CAN 535850. The latter two may provide an evolutionary link between the allopatric species *P. wrightii* and *P. vahliana.*

Taxonomy

***Puccinellia wrightii* var. *flava* (Scribn. & Merr.) Consaul, comb. nov.** Based on *Colpodium wrightii* subsp. *flavum* Scribn. & Merr., Contributions of the United States National Herbarium 13: 75. 1910. The single collection upon which this name is based is more yellow in colour and has larger glumes and florets than in the typical variety. The collection locality lies within the distribution of *P. wrightii* var. *wrightii* and collection notes on specimens suggest the habitats are similar; we, therefore, give this taxon only varietal status.

Note: The combination *Puccinellia wrightii* (Scribn. & Merr.) Tzvelev was published in two places in 1964: Fl. Arct. URSS (Arkticheskaya flora SSSR), Fasc. II, 193. 1964 (IK), and Novosti Sist. Vyssh. Rast. 1964: 19 (GCI). Notes in the respective publications indicate that the former was signed off for publication 18 July 1964 and the latter 14 September 1964. Therefore, the former is the proper citation for the publication of the name *P. wrightii.*

Acknowledgments

We thank Carolyn Parker and Vladim Federov for translation of Russian on herbarium labels, and we also thank the former for providing us with geographical coordinates for some of the more obscure Russian localities. The curators at ALA and US are thanked for loans of specimens. We thank W. J. Cody for collecting *P. arctica* from the Yukon. The Polar Continental Shelf Project is thanked for funding and logistic support for field work, and the Aurora Research Institute and Nunavut Research Institute are thanked for logistic support in the field. J. McNeill, Royal Botanical Gardens, Edinburgh, is thanked for comments and help with nomenclature. Two anonymous reviewers are thanked for constructive comments on the manuscript. This research was funded by the Canadian Museum of Nature. This is Polar Continental Shelf publication #023-06.

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Received 22 August 2002
Accepted 13 September 2005

Appendix 1

Specimens examined in the morphological analyses (names of authors of current paper abbreviated by initials). Herbarium code in parentheses; abbreviations from Holmgren et al. 1990). Specimens used in PCA coded by [P] .

CAN 535850 – N.W.T.: Banks Island, Egg River, Area #16, *K. L. MacInnes s.n.*, 24 July 1971, (CAN)[P]. ***P. agrostidea*** – NUNAVUT, Banks Island: De Salis Bay. 71°26'N, 121°40'W., 31 July 1949, *A. E. Porsild 17614* (CAN) Holotype[P]; Ellesmere Island: Lake Hazen. 81°49'N, 71°20'W., 8-10 Aug. 1961, *C. R. Harington, 355* (CAN)[P]; Caledonian Bay. 79°57.23'N, 81°11.96"W., 9 Aug? 1972, *Waterton, I. W207* (CAN)[P]; Victoria Island: Cambridge Bay. 69°07'N, 105°03'W., 12 August 1959, *Porsild, A. E. 21599* (CAN)[P]; 69°07'N, 105°03'W., 12 August 1959, *Porsild, A. E. 21597* (CAN)[P]. ***P. arctica*** – NUNAVUT: Victoria Island: Cambridge Bay, 69°08'N, 105°10'W, *LJG & LLC 6321* (CAN); *LJG & LLC 6322*; *LJG & LLC 6342* (CAN); NWT: Anderson River Delta, 69°40.66'N, 128°54.92'W, *LJG & LLC 6362* (CAN); Atkinson Point, appr. 70°N, 131°20'W, *A. E. & R. T. Porsild 2549* (CAN); Cape Dalhousie, 70°11.28'N, 129°40.96'W, *A. E. & R. T. Porsild 2710* (CAN)[P]; Tuktoyaktuk, 69°27'N, 133°02'W, *A. E. Porsild 7404*[P]; *J. M. Gillett 18669* (CAN)[P]; *J. M. Gillett 18787* (CAN)[P]; Yukon: Herschel Island, *W. J. Cody 36154* (CAN)[P]. ***P. colpodioides*** – RUSSIA: prov. Magadan, Wrangel Is., 27 July 1970, *V. Petrovsky 6303* (ALA)[P]; *R.P Nebrobikuit*, 28 July 1972 (ALA)[P]; Somnitelnay Bay, vic. Zvzdnyy, approx. 70°50'N, 179°30'W, *V.V. Petrovsky*. 7 August 1971 (voucher 2*n*=14) (ALA)[P]. ***P. poacea*** – NUNAVUT: Axel Heiberg Island: Diana Lake, appr. 79°30'N, 88°30'W, *A. E. Porsild 18640* (CAN)[P]; *A. E. Porsild 18641* (CAN)[P]; Mokka Fiord, 79°29'N, 87°22'W, *LJG & C. Vogel 6087* (CAN); Ellesmere Island: Hazen Camp, 81°49'N, 71°20'W, *LJG & C. Vogel 6215* (CAN); *LJG & C. Vogel 6216* (CAN); *LJG & C. Vogel 6217* (CAN); Hot Weather Creek, 79°58'N, 84°26'W, *LJG & C. Vogel 6132* (CAN); *LJG & C. Vogel 6144* (CAN); *LJG & C. Vogel 6150* (CAN); *LJG & C. Vogel 6151* (CAN); Slidre Fiord, appr. 80°00'N, 85°57'W, *J. S. Tener 33* (CAN); *J.S. Tener 35,* (CAN) Holotype[P]; *J. S. Tener 34* (CAN)[P]; Tanquary Fiord, 81°24'N, 76°52'W, *J. S. J. Haight 6* (CAN)[P]. ***P. vahliana*** – NUNAVUT: Baffin Island: Nanisivik Airport, 73°02'N, 84°33'W, *LJG, LLC & R. J. Soreng 6691* (CAN); Savage Harbour. 61°50'N, 65°45'W, *V. C. Wynne-Edwards 7301* (CAN)[P]; Cornwallis Island: Resolute Bay, 74°41'N, 94°50'W, *LJG & C. Vogel 6249* (CAN); *A. E. Porsild 21649* (CAN)[P]; Devon Island: Dundas Harbour, 74°31.3'N, 82°33.5'W, *LJG, LLC & R. J. Soreng 6697* (CAN); Ellesmere Island: Caledonian Bay, 79°57.23'N, 81°11.96'W, *LLC & LJG 2219* (CAN); Craig Harbour, 76°12'N, 81°01'W, *J. D. Soper 111374* (CAN)[P]; Hazen Camp, 81°49'N, 71°20'W, *LJG 6012* (CAN); NWT, Banks Island: near Cape Lambton, 71°05'N, 123°09'W, *A. E. Porsild 17539* (CAN)[P]; Melville Island: Ibbett Bay Camp, 75°54'N, 114°30'W, *S. G. Aiken & S. A. Edlund 3936* (CAN)[P]. ***P. wrightii*** – RUSSIA: Chukotka Peninsula, in the vicinity of the Chaplin Cape, 20 July 1958, *R. Satpuisau s.n.* (ALA)[P]; Chukotka Peninsula, SE tip of Cape Chaplino, approx. 64°25'N, 172°15'W, 20 July 1958, *V. Gavreluk* (ALA)[P]; Chukotka Peninsula, eastern region, S coast of Lavrentiya Bay, vicinity of Lavrentiya, approx. 65°45'N, 171°W, 29 August 1971, *N. A. Sekretarova, A. K. Sitinn, B. A. Yurtsev* (ALA)[P]; Chukotka Peninsula, eastern tip, vicinity of Uelen, approx. 66°10'N, 169°50'W, 25 Aug. 1971, *N. A. Sekretarova, A. K. Sitinn, & B. A. Yurtsev* (ALA)[P]; SW portion of Chukotka peninsula, right bank of Senevem R., 15 km above mouth. 24 July 1983, *A. E. Katenen & N. A. Sekretarova* (ALA); W. Chukotka, Anyuyskiy Mountains, upper Vernitakatvem River, 12 July 1974, *T. Koraseva and V. Petrovsky* (ALA), voucher 2*n*=14; Siberia, Arakamtchetchene or Kayne Island, *C. Wright* (US ex NA 592344) (Holotype). USA: Alaska, Teller Quad., Cape Prince of Wales, 65°37'N, 168°05'W, 18 August 1982, *T. Kelso 82-230* (ALA); ***P. wrightii* var. *flava***: Alaska, Port Clarence, 65°16'N, 166°51'W. *F. A. Walpole 1891a* (US 379007) (Holotype).

Appendix 2

Morphology and Habitat Description of CAN 535850

Plants 8-18 cm tall; uppermost ligule 0.9-1.0 mm long; inflorescence 2.0-4.0 cm long, inflorescence length to plant height ratio 0.17-0.25; inflorescence lowest branches ascending to horizontal, (2-) 4-5 branches at the lowest node; first glume 2.1-2.2 mm long, 0.6-0.8 mm wide; second glume 2.9-3.2 mm long, 0.7-1.0 mm wide; lemma 3.5-4.0 mm long, with moderate to very wide hyaline margin, longitudinal ridges distinct, base pilose to moderately villous on and between the veins; palea keels distally moderately scabrous, basally glabrous to slightly pilose; anthers 1.6-1.8 mm long. Differs from *P. colpodioides* and *P. vahliana* by its open panicle, smaller ratio of inflorescence to height, relatively narrower glumes, and non-villous palea keel bases; from *P. wrightii* by its larger ratio of inflorescence to height and shorter lemma with a wider hyaline margin; from *P. wrightii* var. *flava* by its non-yellow colour of florets and smaller glumes, lemma and palea, and longitudinal ridges on lemma.

Specimen CAN 535850 was found above the Egg River floodplain in a transition zone between a slightly steeper slope with soil stripes and more pronounced *Dryas/Salix* hummocks below, and a more open summit zone with *Dryas*, *Salix*, *Saxifraga tricuspidata* Rothb. and *Cetraria* above. The collection site had a gradual slope, with 30% ground cover of rounded soil mounds or micropolygons, and predominantly *Dryas/Salix* cover. The plant was found on the bare to partly bare tops of these low *Dryas* mounds, with salt crust, sand, pebbles and desiccation cracks containing lichens and mosses. Scattered small depressions in the area contained predominantly sedges and grass, as well as *Cassiope tetragona* (L.) D.Don. Other associated herbs in the general area were: *Hulteniella integrifolia* (Richardson) Tzvelev, *Parrya arctica* R.Br., *Saxifraga oppositifolia* L., *Astragalus alpinus* L., *Pedicularis capitata* Adams, and *Pedicularis langsdorfii subsp. arctica* (R. Br.) Pennell.

"Prairie Grouse", *Tympanuchus cupido* × *phasianellus*, Hybridization on Manitoulin Island, Ontario

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Lumsden, H. G. 2005. "Prairie Grouse", *Tympanuchus cupido* × *phasianellus*, hybridization on Manitoulin Island, Ontario. Canadian Field-Naturalist 119(4): 507-514.

Greater Prairie Chickens started their range expansion from Wisconsin about 1900. They reached Sault Ste. Marie, Ontario, by 1925 and completed colonization of Manitoulin Island by 1945. In the fall of 1932, an irruption of Northern Sharp-tailed Grouse from the Hudson Bay Lowlands occurred. Residents of Manitoulin distinguished the two species and reported the presence of "square-tails" and "sharp-tails" in the winter of 1932-1933. There is no specimen evidence or verbal reports that Northern Sharp-tailed Grouse reached Michigan during that irruption. Prairie Sharp-tailed Grouse were in the northern peninsula of Michigan by 1930. In 1941, Michigan Department of Natural Resources made a planting of 37 Prairie Sharp-tailed Grouse on Drummond Island. Thence they spread east and the first lek was found at the west end of Manitoulin Island in 1952. By 1960, these birds had virtually colonized the whole island. Development of a hybrid index from the morphology of specimens of skins and skeletons from Manitoulin indicated that more than 50% of all birds in the 1960s were hybrids. In Michigan, less than 1% of the birds necropsied or checked in hunters' bags were hybrid. It seems likely that ethological isolation broke down on Manitoulin Island. The booming display of the Prairie Chicken and the tail rattling display of the Sharp-tailed Grouse can be broken down into their component parts. They appear to be homologous to five discrete displays of the Spruce Grouse, grouped in different patterns in each of the two lek species. There was little hybridization between Prairie Sharp-tailed Grouse and Prairie Chickens that had lived sympatrically for thousands of years. Northern Sharp-tailed Grouse had probably never lived sympatrically with Prairie Chickens and the evolution of the perception of species distinctions may not have evolved to the point where hybridization was restricted to a rare event.

Key Words: Greater Prairie Chicken, *Tympanuchus cupido*, Sharp-tailed Grouse, *Tympanuchus phasianellus*, hybrids, behaviour, Manitoulin Island Ontario, Michigan.

In Ontario during the last 150 years the ranges of many species of birds have changed dramatically (Snyder 1957), mostly as a result of introduction and later intensification of European farming methods and logging. Their effect in Michigan and the adjacent areas of Ontario have altered the habitat and allowed the sequential invasion of Manitoulin Island by Greater-Prairie Chickens (*Tympanuchus cupido*) and two races of Sharp-tailed Grouse (*Tympanuchus phasianellus*).

Land use in the Manitoulin area is largely dictated by the geology of the Island. Almost horizontally bedded ordovician limestone slightly tilted toward the south is generally covered with shallow soils. Only about 12% of the island has soils deep enough for farming. Over 40 500 ha (about 25% of the island) is limestone plain which is largely open because of grazing by cattle and pulp-wood cutting. Both of these uses created and have steadily enlarged the prairie-like appearance of the landscape (Braffette and Brown 1948*). However, that land use is changing today and there is less grazing and pulp-wood cutting.

Although unlike the traditional range occupied by Prairie Chickens and Sharp-tailed Grouse prior to European settlement, it proved to be suitable and was colonized. In this paper I outline the history of the three invasions of Manitoulin Island by three forms of "Prairie Grouse" and offer some hypotheses concerning the development of the hybrid population. Although not an inhabitant of prairie, I shall refer to the Northern Sharp-tailed Grouse (*T. p. phasianellus*) and the mixed population of Manitoulin Island collectively as "Prairie Grouse" in this paper.

History of Prairie Grouse on Manitoulin Island

Prairie Chickens and Sharp-tailed Grouse were sympatric over a wide area in southern Wisconsin in pre-and early settlement times (Schorger 1944). They were ecologically isolated, with the Prairie Chicken occupying the open Long-Grass Prairie and the Sharp-tailed Grouse confined to the Oak openings and brushy areas. With the advent of lumbering and settlement, new range appeared to the north, east and west of their historic distribution and extraordinary range expansions took place. Prairie Chickens moved west almost to the foothills of the Rocky Mountains and as far as one hundred and fifty kilometres north of Edmonton (Houston 2002). They also spread to the northeast, followed twenty years later by the Prairie Sharp-tailed Grouse (*T. p. campestris*), terminating on Manitoulin Island, Ontario.

Between 1875 and 1920 the original range of both species was being converted to farmland and new range in the north was being created by lumbering followed by fire (Hamerstrom et al. 1957). Parts of every county but not all townships in Wisconsin were affected.

Prairie Chickens

The first Prairie Chickens to enter the Upper Peninsula of Michigan presumably came from Wisconsin about 1900 (Ammann 1950*, 1957). They spread across the Peninsula reaching the western half of Chippawa County in 1923-1924. This county includes the northeastern part of the Upper Peninsula adjacent to St. Joseph's Island and the Sault Ste. Marie area of Ontario.

Baillie (1947) wrote, "The first indication that these birds were expanding their range eastward from Michigan came from the west side of St. Joseph's Island, south of Sault Ste. Marie, where a few appeared about 1925. R. H. Burns of Sault Ste. Marie assured us that by 1946 the birds, although not plentiful, had moved over onto the Canadian mainland and were in occupation of a narrow belt of cleared land along the St. Mary's River up to a distance of three miles inland where the edge of the Pre-Cambrian Shield prevents their further progress." W. E. Gimbly (Ontario Department of Lands and Forests, now Ministry of Natural Resources, personal communication) saw some Prairie Chickens at Echo Bay, twelve miles east of Sault Ste. Marie in the late 1930s and W. St. John (L & F personal communication) said that they also reached the Kirkwood area north of Thessalon about that time. This invasion of this part of Algoma including Manitoulin Island by Prairie Chickens occurred a few years before the spectacular irruption of Northern Sharp-tailed Grouse of 1932-1933.

Some of the residents of Manitoulin Island still remembered in the 1950s the 1932 invasion of Sharp-tailed Grouse. John and Cecil Merrylees saw a flock of "Prairie Grouse" feeding on grain spilled from sleighs on Christmas Eve 1932, on the road west of Indian Point Bridge in Burpee Township. "The flock consisted mostly of "sharptails" but some "square" tails were included" (Baillie 1947). This was the first eyewitness account of both Prairie Chickens and Sharp-tailed Grouse occurring together on the Island. The Indian Point bridge is about 56 kilometres from the western end of the Island. It is unlikely that the Prairie Chickens reached this point during the first year of their presence on the Island. They had been advancing at an average rate of 13.5 kilometres per year in Michigan. Ammann (1950*) reported that they reached the lower Seney marshes in 1910-12 about 270 kilometres to the west. If their rate of advance was relatively steady they may have arrived on Manitoulin Island about four years earlier, about 1928. By 1932 there were probably several leks with breeding populations established on suitable range that lies between Meldrum Bay and Indian Point.

Baillie (1947*) also recorded five additional observations in the 1930s. Only one, from Larry Donaldson, refers definitely to "square" tails being seen near Gore Bay in Gordon Township about 1937. By 1939 they had apparently reached Great Cloche Island near Little Current in Howland Township where W. Wilkinson reported seeing six to eight. They had moved about 55 km in seven years or at an average rate of eight kilometres per year. By 1942, they were reported on Ten Mile Point in Sheguiandah Township and at Manitowaning in Assiginack Townships by C. J. Young (Ontario Lands and Forests, personal communication). They had virtually colonized the entire island.

The only specimen of a Prairie Grouse preserved from the early invasion of the north shore of Lake Huron east of Sault Ste. Marie was collected by Professor N. Rae Brown in the Kirkwood Forest Management Unit north of Thessalon on 13 September 1942. It is a hybrid Prairie Chicken × Sharp-tailed Grouse. Figure 1 maps the advance of the Prairie Chicken in the Michigan-Manitoulin area.

Northern Sharp-tailed Grouse

The breeding distribution of the Northern Sharp-tailed Grouse in Ontario, based largely on the reported location of leks, is confined to peatland muskegs and burns in the north. The First Nations people report leks within a few km of the Hudson Bay coast. Along the southern fringe of their breeding range they breed regularly south to the northern Canadian National Railway line. In some areas they breed further south to where better drained land-forms permit development of forest within which there are a few outlying muskegs large enough to support breeding populations; for example, near Matheson, Tionaga, and the Black Sturgeon area near Lake Nipigon.

There are areas of abandoned or little used cultivated land that lie adjacent or close to occupied muskegs but the Northern Sharp-tailed Grouse seems to be unable to colonize them. Their inability to adapt to grassland habitat perhaps explains their failure to persist in areas to which they irrupted in 1932-1933.

There are about 260 000[2] km of muskeg country in northern Ontario which forms the range of the Northern Sharp-tailed Grouse. In the northern part of this range there are annual fall migrations of these birds into the river courses and to the south particularly in the rockier western parts of Ontario.

Every few years some birds move into the Cochrane area where they come to the gravel roads for grit and are easily shot. When populations are exceptionally high, these fall migrations take the form of irruptions that carry the birds far to the south. Snyder (1935) suggests an irruption in 1865-1866. Fleming (1906) documents an irruption in 1896-1897 that carried birds as far south as Muskoka and Parry Sound Districts.

Snyder (1935) described in detail the irruption of Northern Sharp-tailed Grouse that started in mid-October 1932. By March 1933 the birds had penetrated to many localities in the Parry Sound District. A specimen was preserved which was taken as far south as Bracebridge in Muskoka District, but Snyder did not mention that they reached Manitoulin Island.

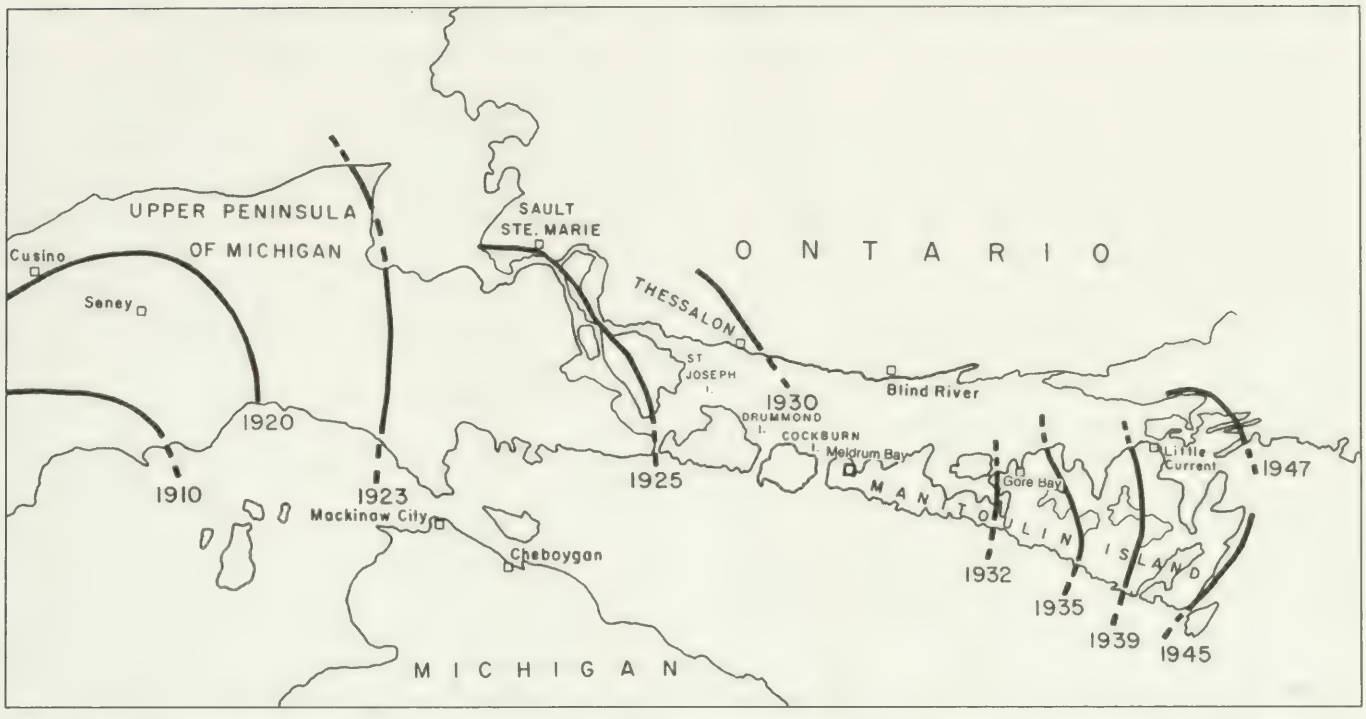

FIGURE 1. Approximate speed of advance of Prairie Chickens in northern Michigan and Manitoulin Island, Ontario.

Although no specimens of Northern Sharp-tailed Grouse from the Island were preserved from the 1932-1933 irruption, there is confirmation in the surviving files of the Department of Game and Fisheries[1] that they did reach Manitoulin Island in 1932. In a letter dated 20 February 1933 J. M. Parks, Superintendent at North Bay, writing of Sharp-tailed Grouse, "On November 5th last it was estimated that several hundreds of birds alighted in the town of Elk Lake, and at the present time small flocks are to be found in the vicinity of North Bay, Sudbury and the Manitoulin Island." He wrote a second letter on 6 March 1933, "Flocks have again been reported in the vicinity of Webbwood and the Manitoulin Island." During this irruption Northern Sharp-tailed Grouse spread over an area of approximately 100 000 square kilometres to the south of their normal breeding range in Ontario. That did not include the area south of the French and Mattawa Rivers where only a few flocks appeared, nor did it include the area the birds occupied in Quebec.

In the Sault Ste. Marie area, a flock of Sharp-tailed Grouse appeared near the school on Lot 11 Concession A of St. Joseph's Township during the winter of 1932 according to Murray Smith (Lands and Forests, personal communication). His brother, F. B. H. Smith, saw a flock of "Prairie Grouse" (species uncertain) about a hundred strong, in the same place in 1935.

Snyder (1935) listed seven observations of young birds or nests with eggs reported from south of the normal breeding area in the summer of 1933. Although there may be an error in any one of these reports, Snyder pointed out, that the aggregate provides "unquestionable evidence that the species nested in territory occupied by the immigrants". However, by the summer of 1934 they had virtually disappeared from their irruptive range.

Prairie Sharp-tailed Grouse

The eastward spread of the Prairie Sharp-tailed Grouse occurred about twenty years after that of the Prairie Chicken. They were assisted in their movement by a release made by the Michigan Department of Conservation. Ammann (1947*) wrote of the Upper Peninsula: "By the early thirties Sharptails had spread to and become abundant in most suitable areas in the western third of the peninsula. Except for Drummond Island, however, they were not commonly noted in the extreme eastern end (Eastern Chippawa and Mackinac Counties) until 1949." Thirty-seven banded Sharp-tailed Grouse were trapped, moved and released in February and March 1941 near Johnswood on Drummond Island (Ammann 1947*). They undoubtedly bred that spring. In 1942 only one bird of fifteen shot was found to have been banded. The population resulting from this successful planting was probably responsible for the subsequent invasion of Cockburn and Manitoulin Islands. Four specimens preserved by H. McQuarrie and B. Smith were shot on Cockburn

[1] Amalgamated in 1946 with the Department of Lands and Forests, the name was later changed to the Ministry of Natural Resources (M.N.R)

Island in November 1950. The birds were abundant there and had evidently been present for some years.

The first specimen of a Prairie Sharp-tailed Grouse on Manitoulin Island was a female shot by W. Ritching on the east bluff at Gore Bay in Gordon Township in 1948. This specimen, given to the author without a label, is now in the Royal Ontario Museum. It is a female in extremely worn plumage. Searches and intensive observations from blinds were carried out between 1949 and 1952 on known leks. No Sharptails were discovered until 1952; it seems likely that this female penetrated well ahead of the main invasion.

On 26 April 1952, I found a Sharp-tailed Grouse lek four kilometres west of Meldrum Bay in Dawson Township, Manitoulin. On 28 April 1952, there were fifteen birds present, four of which were females. Two birds were collected: one was a Sharp-tailed Grouse, and the second was a hybrid. Prairie Sharp-tailed Grouse probably had established their first leks on Manitoulin Island about 1950. On 25 April 1952, a single Sharp-tailed Grouse hen appeared at the lek at the airport near Gore Bay about 50 km from the west end of the Island. H. McQuarrie collected the first male Sharp-tailed Grouse recorded on the central part of the Island on the lek at Britainville, Campbell Township in 1953. Probably about this time males first arrived at the airport at Gore Bay. By 1960, Sharp-tail-like birds were abundant at the Gore Bay airport, Britainville, and in Billings Township where six specimens were collected on 24 September 1960.

In the spring of 1962 the first Sharp-tailed Grouse appeared at the east end of Manitoulin Island in Sheguiandah Township. John Budd (Lands and Forests, personal communication) found a dead bird that may have hit telephone wires beside the road but the species was still scarce. Only Prairie Chickens and hybrids appeared on the two leks in Sheguiandah Township that were studied in 1962. Figure 2 maps the advance of Prairie Sharp-tailed Grouse from Michigan to Manitoulin Island.

The Prairie Chicken stock had colonized, from St. Joseph's Island to eastern Manitoulin, a distance of 187 km in 20 years, an average of about nine km per year. It took the Prairie Sharp-tailed Grouse 21 years to spread from Drummond Island in their year of release to the eastern end of Manitoulin Island, a distance of 137 kilometres at an average speed of six km per year. They were substantially slower than the Prairie Chickens twenty years earlier.

The Hamerstroms (1951), summarizing Wisconsin recovery data, concluded, "...we are convinced... that Prairie Chickens really are somewhat more mobile than Sharptails most of the year." It would appear that if fidelity to the home lek or other behavioural factors did not interfere with changes in home range, Prairie Chickens could be expected to colonize new areas at a faster rate than Sharp-tailed Grouse. Another factor must be considered. Prairie Sharp-tailed Grouse have replaced Prairie Chickens in most of Northern Michigan and the adjacent parts of Ontario. This would suggest that there is competition between the two species in this kind of range. It is likely that the Prairie Chicken was only able to colonize the Sault Ste. Marie-Manitoulin part of Ontario in the absence of competition from Prairie Sharp-tailed Grouse. The mechanisms of competition are at present unknown. It is possible that Sharp-tailed Grouse did not colonize this new range at the same rate as they might have done had the range been vacant of competitors.

History of Prairie Grouse in Northern Michigan

The same genetic stocks of Prairie Chickens and Prairie Sharp-tailed Grouse over-ran the Upper Peninsula of Michigan a few years before they reached Manitoulin Island but there seems to be no evidence that the northern race of the Sharp-tailed Grouse reached Michigan during its irruption in 1932-1933.

I have used Ammann's (1950*) unpublished report on the spread of both species in Michigan as a basis, with modifications according to his (personal communication) subsequent suggestions to estimate the years during which both species were present at the same time in each county.

Using only those years, Table 1 summarizes the data resulting from necropsies by game division biologists and checked in hunters' bags in the field in the Cusino area. Ammann (personal communication) suggested that some hybrids could have been missed before staff were aware that hybrids might be present. In the necropsy sample, 6 of 420 (1.4%) of the birds checked were identified as hybrids. In the Cusino field checks, only 4 of 1206 (0.3%) were identified as hybrids. Combining these hunter bag checks in fall with observations of living birds on their leks in spring, sixteen positive and eight probable hybrids were identified. There were three additional hybrid specimens shot in fall and one seen in spring on Drummond Island.

Johnsgard and Wood (1968) reported many hybrids from three provinces and seven states where the two species occur sympatrically. Their report indicates widespread casual hybridization but nowhere was a hybrid population described. It is clear that the hybrids recorded in Northern Michigan were similarly products of casual cross matings and that at no time did a hybrid population similar to that of Manitoulin Island develop.

We have two areas of range, both of which were occupied by the same genetic stock of Wisconsin Prairie Chickens, but those areas were initially invaded by a different stock of Sharp-tailed Grouse. Casual hybridization occurred in Northern Michigan with the Prairie Sharp-tailed Grouse, whereas a hybrid population resulted on Manitoulin Island with the Northern Sharp-tailed Grouse.

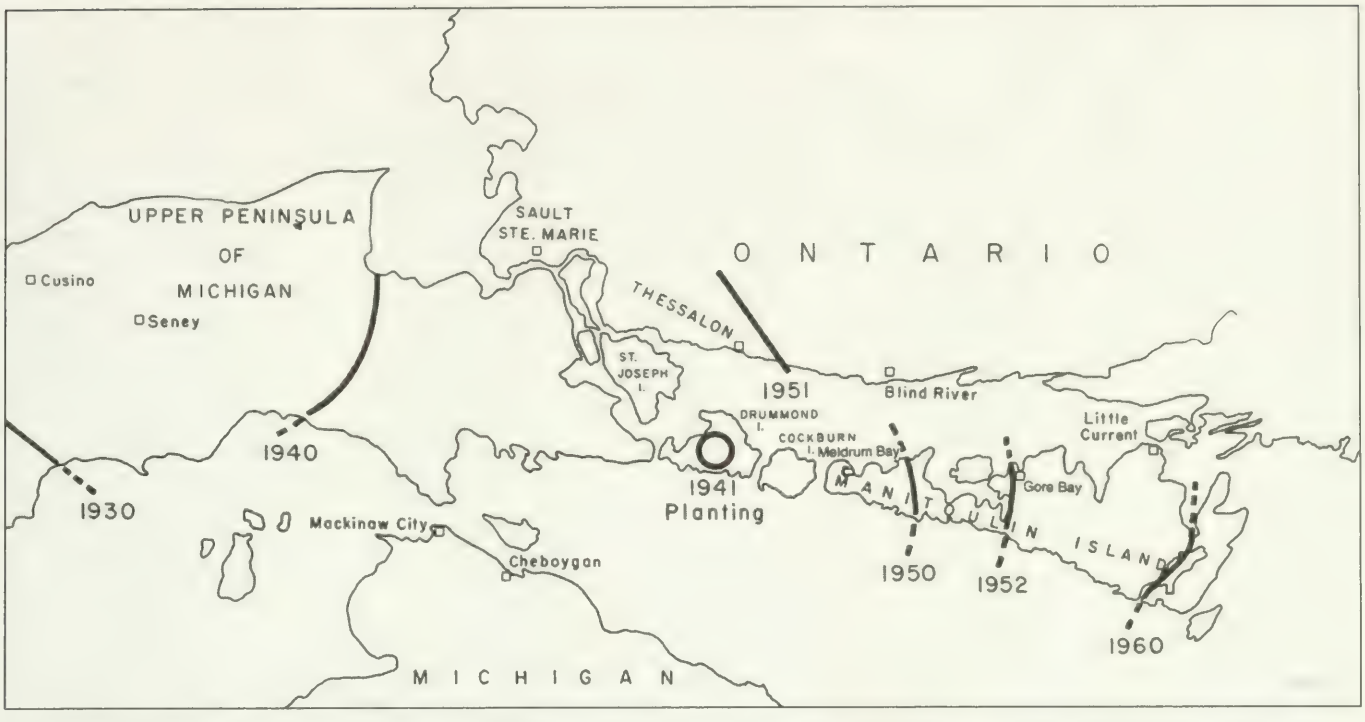

FIGURE 2. Approximate speed of advance of Sharp-tailed Grouse in northern Michigan and Manitoulin Island, Ontario.

Observations on Leks

Starting in 1951, watching from a blind on selected leks on Manitoulin Island, I made judgements on whether each male was a hybrid, a Prairie Chicken, undetermined or a Sharp-tailed Grouse. I used their plumage markings, aberrations in their displays and the colour of their booming sacks and toes. By 1951, Prairie Sharp-tailed Grouse had only reached the extreme western end of Manitoulin Island and none had appeared on the four leks intensively studied. Counts of these leks (Table 2) suggested that of 48 males present, 28 (58%) were hybrids, 16 (33%) were Prairie Chickens, 4 (8%) were undetermined, and none were Sharp-tailed Grouse. Those in the undetermined category had the appearance of Prairie Chickens but slight shortening of the pinnae, or occasional peculiarities of behaviour caused me to question their identity.

By 1962, Prairie Sharp-tailed Grouse had taken over at Gore Bay Airport. There were only 3 (23%) hybrids, no Prairie Chickens, but 10 (7%) apparently pure Prairie Sharp-tailed Grouse.

In 1961, on the extreme eastern end of the Island at the Sheguiandah lek, there were still 10 (83%) hybrids, 2 (17%) Prairie Chickens, and no Sharp-tailed Grouse. Much the same ratios prevailed at Sheguiandah in 1962 when 6 (85%) were hybrids and there was only 1 (15%) Prairie Chicken. However in 1964, Prairie Sharp-tailed Grouse had appeared at Sheguiandah and in 1966 at Ten Mile Point. The proportions of hybrids in each year for each lek studied ranged from 23% to 85% (Table 2).

Discussion

The hybrid frequency on Manitoulin Island amounts to more than 50% of the population (Lumsden in preparation) but in northern Michigan far less than 1%. There are thus significantly different rates of hybridization in these two areas. Prairie Chickens and Sharp-tailed Grouse do not produce hybrid populations wherever they have been sympatric. Mayr (1942) outlined four categories of isolating mechanisms, one or more of which can operate to maintain the genetic integrity of a population. They are: (1.) ecological isolation; (2.) ethological isolation; (3.) mechanical isolation; (4.) genetic isolation.

The hybrid population that developed on Manitoulin Island indicates that there could be no genetic, mechanical or ecologically isolating mechanisms operating. It is likely that ethological isolating mechanisms provided the most effective barrier between the species else-

TABLE 1. Number of Prairie Chickens, Sharp-tailed Grouse and hybrids from the upper peninsula of Michigan necropsied by Game Division biologists 1935-1957 and checked by field staff at Cusino 1939-1954.

	Prairie Chickens	Sharp-tailed Grouse	Hybrids
1935-1957 necropsies	49	371	6[1]
1939-1954 field checks	110	1096	4[2]

[1] first hybrid identified in 1939
[2] two hybrids identified by G. A. Ammann

TABLE 2. Number of male hybrids, Prairie Chickens, Undetermined, and Prairie Sharp-tailed Grouse tallied on various leks in 1951 and 1952 and 1964-1966.

Lek	Hybrid	Prairie Chicken	Undetermined	Sharp-tailed Grouse
1951				
Gore Bay Airport	10 (55%)	4 (22%)	4 (22%)	0
Billing's Township	2 (33%)	4 (66%)	0	0
Britainville	6 (75%)	2 (25%)	0	0
Tustians Farm	10 (63%)	6 (37%)	0	0
Total	28 (58%)	16 (33%)	4 (8%)	0
1952				
Gore Bay Airport	6 (42%)	4 (29%)	4 (29%)	0
Sheguiandah	6 (85%)	1 (14%)	0	0
Total	12 (57%)	5 (24%)	4 (19%)	0
1964				
Sheguiandah	8 (67%)	1 (8%)	0	3 (25%)
1965				
Sheguiandah	6 (60%)	1 (10%)	0	3 (30%)
1966				
Sheguiandah	4 (50%)	2 (25%)	0	2 (25%)
10 Mile Point	4 (57%)	0	0	3 (43%)
Total	8 (53%)	2 (13%)	0	5 (33%)

where and that this broke down on Manitoulin Island.

In non-lek species, such as the Spruce Grouse (*Canachites canadensis*) males that display in isolation on their territories usually must respond at one time to no more than a single visitor of their own species. Thus, on the approach of a rival male the territory holder could react with one or more displays. On the approach of a female the male might respond with courtship displays (Lumsden 1961) and finally by copulation if the hen were receptive.

In a lek-species, however, where territories are very small and many males may be displaying in close proximity, a single male may have to respond simultaneously to a challenge from a dominant neighbour, to an invasion by a subdominant rival or to a visit by a receptive female. Each lek species has a complex display which seems to be appropriate in a variety of circumstances and which is performed endlessly. The lek display of the Prairie Chicken and the tail-rattling display of the Sharp-tailed Grouse are the multi-purpose displays which function in these complex social situations.

Schenkel (1956 and 1958) proposed that these multiple purpose displays of the above species are homologous with the tidbitting displays of many species of pheasant. I cannot agree with this. First, the tidbitting displays so far described for pheasants are all frontal displays, while the booming and tail-rattling displays are lateral in orientation. Second, one can hardly find a single component element in common between tidbitting and the grouse displays.

If we break down these multipurpose displays of lek species into their component parts and look for homologies in the displays of a solitary species (e.g., the Spruce Grouse), we find elements from four different Spruce Grouse displays – hooting, tail flick, strutting and head and tail down displays are telescoped into the booming display of the Prairie Chicken. In the case of the Sharp-tailed Grouse, tail-rattling display elements from the tail swishing, strutting, head-jerk, and head and tail down displays appear. Table 3 summarizes how these elements are grouped. It is important to note that the multipurpose displays of Prairie Chickens and Sharp-tailed Grouse, while homologous with several displays of a solitary species, have the component elements so grouped that the two displays present totally different sounds and appearances to an observer. These differences constitute the behavioural isolating mechanism. Anyone who is familiar with the two species will recognize that it is possible to identify the lek, whether Prairie Chicken or Sharp-tailed Grouse, as far away as the birds can be heard, perhaps two kilometres. Sexually active hens would have no difficulty in locating the lek of their own species in an area of sympatry. Similarly, should a hen make a mistake and visit a lek of the wrong species, the courtship behaviour directed at her would normally tend to correct her mistake.

If these species-specific displays constitute the main isolating mechanism, it is likely that perception by the female of the differences must be present to make them effective. I suggest that the Prairie race of the Sharp-tailed Grouse (*Tp. campestris*) that may have lived sympatrically with Prairie Chickens for thousands of years, through selection, produced a biotype of female in which perception was very sharp. Females of the muskeg-dwelling Northern Sharp-tailed Grouse (*Tp. phasianellus*), which may never have lived in sympatry with the Prairie Chicken, were not subjected to this kind of selection. This may explain the breakdown of species isolation on Manitoulin Island and the production of a hybrid population.

TABLE 3. Elements in Spruce Grouse displays grouped in the booming and tail-rattling displays of Prairie Chickens and Sharp-tailed Grouse.

Spruce Grouse	Prairie Chicken		Sharp-tailed Grouse		
	Booming	Nuptial Bow	Tail Rattling	Cooing	Nuptial Bow
Hooting Display					
inflation of oesophagus	X		Seldom	X	
hooting vocalization	X		Seldom	X	
Tail Flick					
(inhibited locomotion)					
Rapid steps	X		X		
Tail Flicked open	X				
Wings lowered	X				
Strutting/Tail Swishing					
Spreading alternate sides of tail			X		
Wings lowered	X			X	
Inflation of oesophagus	X			X	
Head-Jerk or Squatting					
Wings held open and away from the body		X	X		X
Head and Tail Down					
Head and neck extended forward	X		X		

There are further factors that may have contributed to the production of hybrids. Snyder (1935) reported that the sex ratio of Northern Sharp-tailed Grouse that irrupted in 1932 was grossly distorted. Of the 65 specimens that were preserved in museums, the sex ratio was 74% females to 26% males, most of which were in their first year. Furthermore, the birds that reached Manitoulin Island had no traditional leks at which they could seek matings in the spring of 1933. It is apparent that leks of the resident Prairie Chickens in western Manitoulin attracted traditionless Northern Sharp-tailed Grouse. This occurred again when Prairie Sharp-tailed Grouse invaded Manitoulin Island in the early 1950s. They did not immediately establish leks of their own but appeared at the existing Prairie Chicken and hybrid leks.

An additional factor may have enhanced the opportunity for hybridization and perhaps reduced the influence of the male Sharp-tailed Grouse on the 1933 year class. A lek is composed of a group of males in which an hierarchy of dominance prevails. Repeated observations on both Sharp-tailed Grouse and Prairie Chicken leks have confirmed that only very few males perform all the matings. In some cases, a single alpha male may copulate with 75% of the females that visit the lek (Lumsden 1965*). Among Prairie Chickens, Robel (1967, 1970) reported that two males performed 89% of 121 copulations. The extent to which the Sharp-tailed Grouse males contributed to the 1933 year class would depend on their ability to achieve high status in the lek hierarchies. This would be difficult for them since most were less than one year old.

Snyder (1935) wrote that the Northern Sharp-tailed Grouse disappeared from their acquired range very rapidly and that by the winter of 1933-1934 there were very few left. This population from the muskeg is apparently not adapted to life in grassland and it is likely that most disappeared from Manitoulin within a year. Some may have returned to the north and others died. The hybrids produced in 1933 and the Prairie Chickens were left to continue to interbreed and to colonize the rest of the Island

Table 2 shows that during the invasion by Prairie Sharp-tailed Grouse (*Tp. campestris*), no males had reached the Gore Bay Airport by 1951. However, by 1962 77% of the 13 males present were Sharp-tailed Grouse. At the same time at Sheguiandah on the extreme east end of the island in 1962, there were no Sharp-tailed Grouse among the seven males present. By 1964, 25% of 12 males tallied there were Sharp-tailed Grouse. By 1966, the proportion of Sharp-tailed Grouse had risen to 33% at Sheguiandah and 10 Mile Point.

Field studies were not continued after 1970 but naturalists have maintained an interest in the "Prairie" Grouse of Manitoulin since. Observations made by Jerry Guild (Ontario Field Ornithologists News 1997) on the Gore Bay Airport on 15 April, 1997 yielded a count of 50 Sharp-tailed Grouse. Jean Iron (personal communication) recorded 75-100 Sharp-tailed Grouse on 15 April 2000; 30 on 12 April 2003; and 60 on 11 April 2004 at the Gore Bay Airport. No Prairie Chickens or hybrids were recorded in these years. No naturalist seems to have checked the "Prairie" Grouse on the eastern end of the island. In view of the success of Sharp-tailed Grouse in the Gore Bay area and the time lapse since the last checks, it seems likely that Sharp-tailed Grouse have now displaced Prairie Chickens and hybrids throughout the island.

Acknowledgments

I thank G. A. Ammann for his generous loan of unpublished reports. I thank F. N. and F. Hamerstrom for fruitful discussions on the biology of Prairie Grouse and loan of specimens. The land owners on Manitoulin Island generously permitted me to work on their property. I thank W. Riching, H. McQuarrie, and B. Smith for the many specimens they donated and for help with fieldwork. I am most grateful to A. J. Erskine and an unknown referee who greatly improved this paper.

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Received 25 June 2004
Accepted 29 March 2005

Plumage and Internal Morphology of the "Prairie Grouse", *Tympanuchus cupido* × *phasianellus,* of Manitoulin Island, Ontario

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Lumsden, Harry G. 2005. Plumage and internal morphology of the "Prairie Grouse", *Tympanuchus cupido* × *phasianellus,* of Manitoulin Island, Ontario. Canadian Field-Naturalist 119(4): 515-524.

I made comparisons among populations of Greater Prairie-Chickens, Sharp-tailed Grouse and their hybrids on Manitoulin Island of pinnae length, breast, flank and tail feather patterns, tail graduations, wing chord, and skeletal characteristics. Estimates of the proportion of hybrids from these individual characters ranged from 32% to 60%. Lek behaviour of hybrids was a mixture of the patterns of the parent species. The colour of the booming sacks varied and displayed the range between the parent species.There was a tendency with time for the characters of Prairie Chickens to decline coincident with an increase in Sharp-tailed Grouse characters. Both Prairie Chickens and Sharp-tailed Grouse are lek species in which an alpha male may consummate most of the the matings. The speed with which morphological change took place in Manitoulin Island is to be expected where a non-random mating system of this kind prevails.

Key Words: Greater Prairie-Chickens, *Tympanuchus cupido pinnatus,* Sharp-tailed Grouse, *Tympanuchus phasianellus,* proportion of hybrids, morphology, behaviour, population changes, Heath Hen, *Tympanuchus cupido cupido,* species relationships.

The occupation of Manitoulin Island, Ontario, by Greater Prairie-Chickens (*Tympanuchus cupido pinnatus)* and their hybrids with Northern Sharp-tailed Grouse (*T. p. phasianellus*) was essentially complete by 1945 and offers clues to species relationships. Trapping of these birds started in the winter of 1948-1949 and field studies continued intermittently until 1966, with hunting season collections continuing until 1970. Between 1943 and 1946, Prairie Sharp-tailed Grouse (*Tympanuchus p. campestris*) moved into the western end of the island and reached the eastern end about 1960 (Lumsden 2005).

Specimens of hybrids showed the full range of characters between Greater Prairie-Chickens and Sharp-tailed Grouse. The purpose of this study is to estimate the proportion of hybrids present in the Manitoulin Island population, its change with time and to describe its morphology. Manitoulin specimens are curated at the Royal Ontario Museum in Toronto.

Methods

Manitoulin specimens were sorted into three groups. The samples taken from 1949 to 1959 consisted of Greater Prairie Chickens (*Tympanuchus cupido pinnatus*) and their hybrids with Northern Sharp-tailed Grouse (*Tympanuchus phasianellus phasianellus*). They included specimens from the western end of the island and later the eastern end near or on leks where no Prairie Sharp-tailed Grouse (*Tympanuchus p. campestris*) to that time had been recorded.

From 1960 to 1963, Prairie Chickens, hybrids and Prairie Sharp-tailed Grouse were present in all parts of the island. Between 1964 and 1970, Prairie Chickens had disappeared and the earlier hybrids were interbreeding with Prairie Sharp-tailed Grouse. For comparison with the Manitoulin specimens, Prairie Chickens were borrowed from five museums with specimens from Manitoba, Saskatchewan, Alberta, Michigan, Wisconsin, Minnesota, Iowa, Montana, North and South Dakota, Nebraska, Illinois and Oklahoma. All the Northern Sharp-tailed Grouse were collected in northern Ontario.

Morphological Characters

Pinnae, breast, flank and tail feathers were collected from trapped birds that were released elsewhere. On the pinnae feathers from 9 to 11 mm of the proximal end of the shaft were white and were embedded in tissue. Measurements were taken from the terminus of the white on the shaft to the tip of the feather. Measurements were taken from study skins by sliding a thin ruler under the longest feather and reading from the skin to the tip.

The pinnae lengths were divided into five groups: Class 1: 84-72 mm; Class 2: 71-59 mm; Class 3: 58-46 mm; Class 4: 45-33 mm; and Class 5: 32-20 mm (Table 1). Feathers from the upper breast (Figure 1) (Table 2) and the lower flanks (Figure 2) (Table 3) were selected to represent the range of pattern variation seen in the three populations. These were arranged into five pattern classes ranging from the barred Prairie Chicken pattern (Class 1) to the acute- angled arrow-shaped pattern (Class 5) of the Sharp-tailed Grouse. The equivalent feathers on all specimens were matched with these patterns and a relevant value assigned. Figure 3 illustrates the steeply graduated tail of a male Sharp-tailed Grouse. Graduation was the length of the outer tail feathers subtracted from the length of the central tail feathers. Measurements were taken from where the feather emerged from the skin to the tip.

Division of the measurements of the degree of graduation of the tail into five groups were Class 1: 30-44 mm,

TABLE 1. Classes of length of the pinnae of male Prairie Chickens, the Manitoulin population and Northern Sharp-tailed Grouse.

Class	1	2	3	4	5	Total
Prairie Chicken	100 (77%)	30 (23%)	0	0	0	130
Manitoulin 1949-1959	7 (11%)	30 (39%)	11 14%)	4 (5%)	24 (32%)	76
Northern Sharp-tailed Grouse	0	0	0	0	19 (100%)	19

FIGURE 1. Upper breast feathers from a Prairie Chicken, three hybrids and a Sharp-tailed Grouse showing range of variation.

Class 2: 45-58 mm, Class 3: 59-73 mm, Class 4: 74-87 mm and Class 5: 88-102 mm (Table 4). Figure 4 illustrates the pattern on the tail feathers of a male Prairie Chicken, a female and four male Sharp-tailed Grouse. The pattern on the latter varies in males and is often an indicator of sex (Table 5).

There was a small overlap in the length of the wing (chord) between Prairie Chickens and Northern Sharp-tailed Grouse. The wing lengths were divided into Class 1: 239-230 mm; Class 2: 229-220 mm; Class 3: 219-210 mm; Class 4: 209-200 mm; and Class 5: 199-190 mm (Table 6).

Skeletons were saved from as many specimens as possible. Measurements were taken from the tip of the ilium process to the ventral surface of the pubic bone. In cases where the ilium process projected below the pubic bone, a minus value was assigned. Figure 5 shows the lateral view of the ilium and ischium of Prairie Chickens, Heath Hens (*Tympanuchus cupido cupido*), (see note page 000) and Northern Sharp-tailed Grouse. Size classes summarized in Table 7 were as follows: Class 1: -2.5- +0.7 mm; Class 2: 0.8-4.0 mm; Class 3: 4.1-7.3 mm; Class 4: 7.4-10.6 mm; and Class 5: 10.7-13.9 mm. The vertebral column consists of a

TABLE 2. Classes of patterns on the upper breast feathers of male Prairie Chickens, the Manitoulin Island population and Northern Sharp-tailed Grouse.

Class	1	2	3	4	5	Total
Prairie Chickens	175 (100%)	0	0	0	0	175
Manitoulin 1949-1959	14 (42%)	9 (27%)	6 (18%)	3 (9%)	1 (3%)	33
Manitoulin 1960-1963	8 (12%)	8 (12%)	12 (19%)	9 (14%)	27 (42%)	64
Manitoulin 1964-1970	2 (4%)	5 (9%)	11 (21%)	11 (21%)	24 (45%)	53
Northern Sharp-tailed Grouse	0	0	0	0	66 (100%)	66

FIGURE 2. Lower flank feathers from a Prairie Chicken, three hybrids and a Sharp-tailed Grouse showing range of variation.

TABLE 3. Classes of patterns on the feathers of the lower flank feathers in male Prairie Chickens, the Manitoulin Island population and Sharp-tailed Grouse.

Class	1	2	3	4	5	Total
Prairie Chickens	174 (100%)	0	0	0	0	174
Manitoulin 1949-1959	11 (33%)	11 (33%)	2 (6%)	2 (6 %)	7 (21%)	33
Manitoulin 1960-1963	5 (8%)	3 (4%)	7 (11%)	7 (11%)	42 (66%)	64
Manitoulin 1964-1970	0	4 (7%)	3 (6%)	8 (15%)	38 (72%)	53
Northern Sharp-tailed Grouse	0	0	0	3 (4%)	63 (95%)	66

TABLE 4. Degree of graduation of the tail of male Prairie Chickens, the Manitoulin population and Northern Sharp-tailed Grouse.

Class	1	2	3	4	5	Total
Prairie Chickens	144 (99 %)	2 (1%)	0	0	0	146
Manitoulin 1949-1959	39 (67 %)	13 (22%)	4 (7%)	2 (3%)	0	58
Manitoulin 1960-1963	5 (16 %)	3 (9%)	13 (40%)	7 (22%)	4 (13%)	32
Manitoulin 1964-1970	0	2 (11%)	8 (42%)	9 (47%)	0	19
Northern Sharp-tailed Grouse	0	0	0	29 (39%)	45 (61%)	74

TABLE 5. Frequency of males from Manitoulin Island classified as Sharp-tailed Grouse by criteria other than the tail pattern and as hybrids, which showed a pattern of lines parallel to the shaft on the central tail feathers.

	Classified as Sharp-tailed Grouse		Classified as Hybrids	
	With Pattern	Without Pattern	With Pattern	Without Pattern
1949-1959	1	0	0	39
1960-1963	4	13	2	28
1964-1970	7	3	5	21
Total	12 (43%)	16 (57%)	7 (7%)	88 (93%)

TABLE 6. Classes of the length of the wing (chord) of male Prairie Chickens, the Manitoulin population and Northern Sharp-tailed Grouse.

Class	1	2	3	4	5	Total
Prairie Chickens	31 (20%)	105 (69%)	17 (11%)	0	0	153
Manitoulin 1949-1959	0	11 (36%)	14 (47%)	5 (17%)	0	30
Manitoulin 1960-1963	0	8 (13%)	37 (60%)	16 (26%)	1 (2%)	62
Manitoulin 1964-1970	0	2 (4%)	16 (31%)	22 (42%)	12 (23%)	52
Northern Sharp-tailed Grouse	0	0	2 (2%)	58 (73%)	20 (25%)	80

TABLE 7. Distance from the tip of the ilium process to the ventral surface of the pubic bone in male Prairie Chickens, the Manitoulin population, and Sharp-tailed Grouse.

Class	1	2	3	4	5	Total
Prairie Chickens	27 (87%)	4 (13 %)	0	0	0	31
Manitoulin 1949-1959	12 (36 %)	11 (33 %)	7 (21%)	3 (9%)	0	33
Manitoulin 1960-1963	2 (4%)	5 (10%)	6 (12%)	9 (18%)	28 (56%)	50
Manitoulin 1964-1970	0	0	3 (9%)	12 (34%)	20 (57%)	35
Northern Sharp-tailed Grouse	0	0	0	11 (28 %)	28 (72%)	39

variable number of bones, particularly among the hybrids. I follow Campbell and Lack (1985) in their definitions of subdivisions. The cervical or neck vertebrae are free with the posterior one carrying a floating rib. The thoracic or dorsal vertebrae carry ribs articulated through sternal ribs with the sternum.

Four thoracic vertebrae are normally fused to one another but a fifth is free. The sixth is fused to the lumbar vertebrae and carries a rib that articulates with the neighbouring sternal rib but not directly with the sternum. The lumbar and sacral vertebrae, which form the synsacrum, are fused to one another but some to the ilium. I have counted as caudal or tail vertebrae those that are free. However, the number varies with age. The anterior one may fuse with the synsacrum in old birds. I did not include in Table 8 very young birds that had not completed fusion of the synsacrum. The vertebral column ends with the pygostyle.

Results

Length of the Pinnae

Prairie Chickens have a tuft of feathers 70-85 mm long on the sides of the neck above the anterior edge of the booming sac. On the Sharp-tailed Grouse, the equivalent feathers are only about 23 mm long. Table 1 presents the number of birds with pinnae in each class for Prairie Chickens, Manitoulin Island specimens, and Northern Sharp-tailed Grouse. Because 77% of the Prairie Chickens are in Class 1, we should consider that 77% of 7 Manitoulin birds are also Prairie Chickens leaving only two hybrids in that class. In Class 2, there are 30 (23%) of the Prairie Chickens. Therefore, 23%

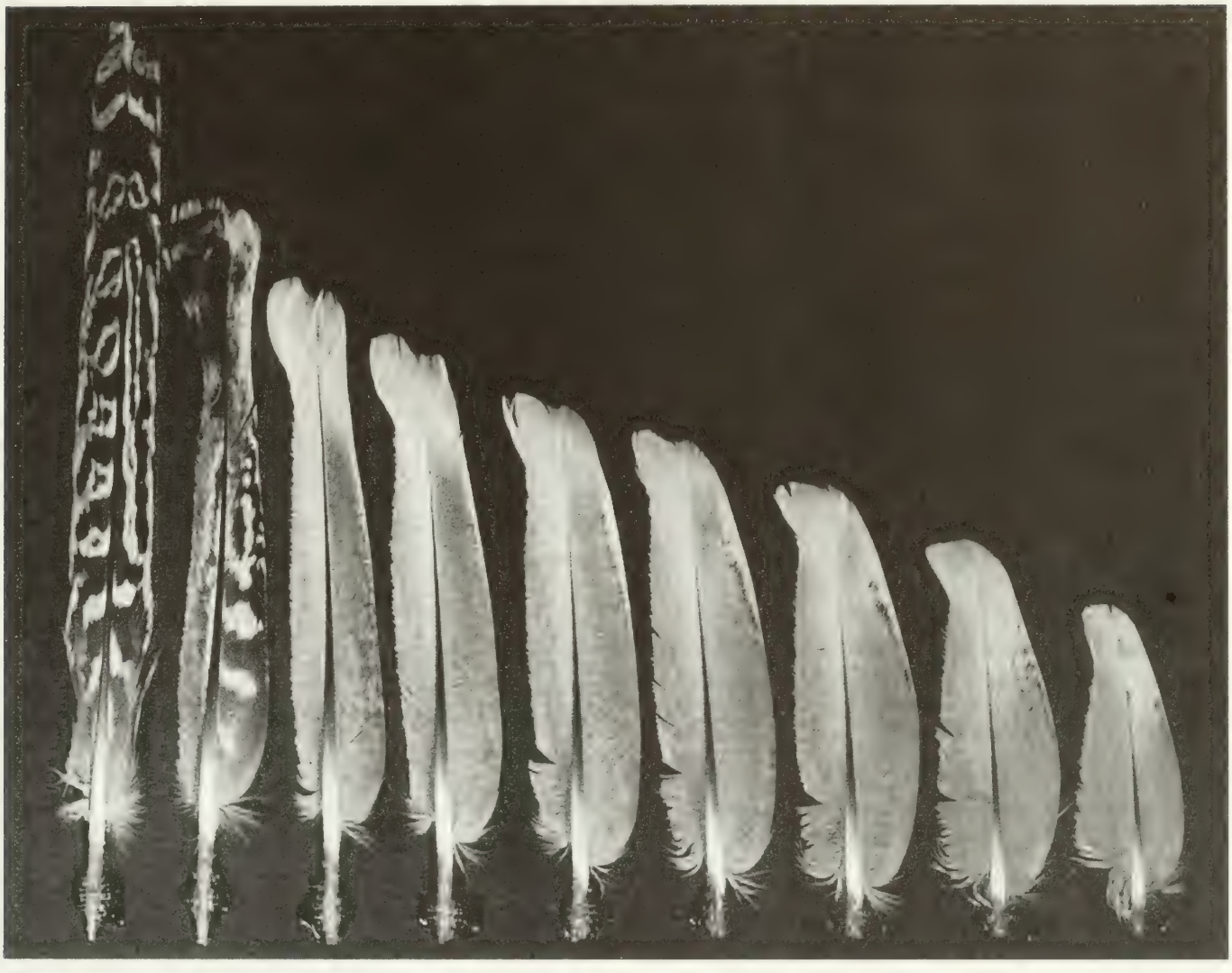

FIGURE 3. Feathers illustrating the steeply graduated tail of a male Sharp-tailed Grouse.

of 30 Manitoulin birds must be considered to be Prairie Chickens, leaving 23 hybrids. All the Manitoulin birds in Class 3 and 4 must be considered hybrids, totalling 15. All the Sharp-tailed Grouse were placed in Class 5 so we must consider the 24 Class 5 Manitoulin Grouse as Sharp-tailed Grouse. Left are 40 probable hybrids out of 76 specimens from Manitoulin or 52 %. It was unfortunate that nearly all specimens collected in fall during hunting seasons of 1960 to 1970 were molting with pinnae and tail feathers not fully grown.

Fred and Frances Hamerstrom graciously let me measure their collection of 275 pinnae of Prairie Chickens collected in Wisconsin. The mean for those Wisconsin specimens was 77.7 mm whereas the maximum for Manitoulin birds was 75 mm.

Pattern on the Upper Breast Feathers

As all Prairie Chickens were assigned to Class 1 (Table 2), we must assume that all Manitoulin specimens in Class 1 were also Prairie Chickens. All Sharp-tailed Grouse fell into Class 5, therefore all Manitoulin birds in Class 5 should be considered to be Sharp-tailed Grouse. The remaining 74 Manitoulin grouse constituting 49% of the sample can be regarded as hybrids.

Patterns on the Lower Flank Feathers

All Prairie Chickens were placed in Class 1 (Table 3), so we must consider all the Manitoulin specimens falling into this class as being Prairie Chickens. In Class 4 only 4% were Sharp-tailed Grouse leaving 16 hybrids. With Class 5 birds from Manitoulin, all but 3 (5%) must be considered as Sharp-tailed Grouse. There were 49 hybrids among the Manitoulin sample or 32%.

Tail Graduation

The tail feathers of a Sharp-tailed Grouse are very steeply graduated. The outer pair is only about 35% of the length of the central ones. In the Prairie Chicken, the tail is almost square with the outer rectrices measuring about 71% of the pair at the centre. The degree of graduation was the difference in length between the outer and central pair. It should be noted that the central pair of tail feathers in both species does not emerge from the tissue on the same plane as the eight pairs of rectrices. They grow on the same plane as the upper tail

TABLE 8. Counts of cervical, thoracic, synsacral and caudal vertebrae of Prairie Chickens,the Manitoulin populations and Sharp-tailed Grouse, all years and both sexes combined.

	Cervical Vertebrae		Thoracic Vertebrae			Synsacrum			Unfused Caudale			Number of birds in the sample
	15	16	5	6	7	11	12	13	5	6	7	
Greater Prairie Chicken	33	0	0	38	0		13	31	19	11	0	38
Manitoulin Population	56	2	1	28	6	2	21	16	19	24	1	58
Sharp-tailed Grouse	53	0	0	47	1*	4	46	3	0	31	8	53

* one extra thoracic but missing one lumbar

coverts and should properly be recognized as modified tail coverts. Table 4 presents the measurements broken down into five classes. As 44 of the Manitoulin birds were placed in Class 1 with 99% of the pure Prairie Chickens, there is a possibility that none of them were hybrids. Two (1%) of the Prairie Chickens were placed in Class 2. A few of the Class 2 Manitoulin birds may have been pure Prairie Chickens. Adjusting their numbers by 1% should provide an estimate of 17 hybrids, 29 (39%) of the Sharp-tailed Grouse were placed in Class 4. The number of hybrids in Class 4 must be reduced from 18 to 11. In Class 5, the number of true hybrids is likely to have been 2. Most of the specimens in Class 5 were collected during the molt hence the small sample size. Out of 109 Manitoulin specimens, 55 or 50% do not conform to this character of either parent species and can be considered hybrids.

Tail Pattern in Sharp-tailed Grouse

The central tail feathers of many male Sharp-tailed Grouse (e.g., #217, Figure 4) are distinctive with lines running parallel to the shaft. Females have irregular bars running across the feather. A proportion of the males lack the line pattern and have a barred pattern that is somewhat similar to that of a female (Figure 4). About 86% of the Prairie Sharp-tailed Grouse males have the distinctive line pattern; 14% do not (Snyder 1935; Manwiler 1939). In the male Northern Sharp-tailed Grouse I have examined, 12% are lacking the lines running parallel to the shaft. Examination of the specimens from Manitoulin Island did not adhere to the above pattern. Of 28 males classified as Sharp-tailed Grouse by other criteria, one would expect that 3 (12%) or 4 (14%) would lack the line pattern. In fact, 57% were without this character, a rate four or five times higher than expected. Of males classified as hybrids, 93% lacked the line pattern (Table 5).

The dorsal surfaces of the rectrices of male Sharp-tailed Grouse are very pale grey and are white at the tips. In hybrids, this part of the tail is a darker grey even in those that approach Sharp-tailed Grouse in other characters. Prairie Chickens have all the rectrices and even the central modified tail coverts dark in colour with some lighter coloured bars or spots.

Length of the Wing

The lengths of the wings of Prairie Chickens and Northern Sharp-tailed Grouse overlap slightly, but the former average distinctly larger (Table 6). There were no Manitoulin birds in Class 1. In Class 2, 69% were Prairie Chickens, leaving 7 probable hybrids. In Class 3, of the 67 Manitoulin specimens, about 14% could be either Prairie Chickens or Northern Sharp-tailed Grouse, leaving 58 probable hybrids. Class 4 contained 43 Manitoulin specimens but there were 58 (73%) Northern Sharp-tailed Grouse, leaving 12 probable hybrids. Class 5 contained 25% of the Northern Sharp-tailed Grouse, therefore 10 of 13 Manitoulin birds were most likely to be hybrids. Those adjustments produced an estimate of 60% hybrids.

Distance from the Tip of the Ilium Process to the Pubic Bone

There is a substantial difference in the shape of the pelvic area between the Prairie Chicken and the Northern Sharp-tailed Grouse. In the former, the ilium process projects ventrally so that it overhangs the ischium and occasionally even projects beyond and below the pubic bone (Figure 5). In the Northern Sharp-tailed Grouse it projects laterally, barely obscuring the ischiadic foramen. Table 7 records that 87% of the Prairie Chickens were in Class 1. We can assume that only 2 of the 14 Manitoulin birds in Class 1 were hybrids. In Class 2, 13% must be regarded as Prairie Chickens leaving 14 probably hybrids. All 16 Class 3 Manitoulin birds were hybrids. Among the Sharp-tailed Grouse, 28% were in Class 4, so our estimate of hybrids is 17. As Class 5 contained 72% of the Sharp-tailed Grouse, we can estimate only 14 of 48 from Manitoulin as hybrids. Thus, 63 Manitoulin specimens were probable hybrids constituting 53% of the 118 samples.

FIGURE 4. Central rectrices from a male Prairie Chicken, one female and four male Sharp-tailed Grouse showing variation in markings.

Vertebral Column

Skeletons available, not all complete, were 38 Prairie Chickens, 58 from the Manitoulin population and 53 Northern Sharp-tailed Grouse. Table 8 summarizes the numbers of vertebrae in each sector of the spine for the three populations. The only variation in the cervical vertebrae occurs among the Manitoulin birds, 2 of which had an extra cervical vertebra. Counts of the thoracic vertebrae among the Manitoulin specimens revealed that one bird possessed only 5 but six had 7 (17% of the series). Among the caudal vertebrae of all three populations there was variation. None of the Prairie Chickens had seven, none of the Northern Sharp-tailed Grouse had five, but nineteen hybrids had five and one had seven.

Not only is there variation in the number of vertebrae in each sector of the spine of the Manitoulin birds, but there is also variation in the structure of the bones. Table 9 summarizes six categories of aberrations that appeared in the vertebral columns. Of the 38 Prairie Chickens studied, three (8%) had aberrant structures. Of the 58 Manitoulin specimens, 24 (41%) were abnormal in structure. Among the Northern Sharp-tailed Grouse, two (4%) of 53 showed abnormalities. Many of those aberrations might not affect the functioning of the bird as far as survival was concerned. More serious abnormalities such as fusion or missing vertebrae might influence survival, possibly in situations of escape from avian predators. More serious but unmeasured in this study would be possible aberrations in

TABLE 9. Number of specimens with aberrant structures in the vertebral column in Prairie Chickens, the Manitoulin population and Sharp-tailed Grouse.

Category of aberrance	Prairie Chicken	Manitoulin Population	Sharp-tailed Grouse
Five dorsals fused	1	2	0
All six dorsals fused	0	3	0
Vestigial rib on the anterior lumbar	0	9	1
One missing lumbar	0	1	0
Incomplete parapophyses connecting the lumbar with the ilium	2	8	1
Posterior dorsal not properly fused to the lumbar	0	1	0
Total	3	24	2

muscle tracts, mixed behavioural signals or improper responses to external threats.

In mature Prairie Chickens there are five or six free caudal vertebrae (Table 8). In Sharp-tailed Grouse there are six or seven. The evolution of the tail rattling display in the latter would likely have carried with it a change in the mobility and muscular structure of the tail, hence the increase in the length of the tail and its capacity for movement. The pygostyle is generally considered to be composed of a number of fused caudal vertebrae. As both these species have eight pairs of rectrices, it may be reasonable to assume that the pygostyle is composed of at least eight fused caudal vertebrae.

Behaviour

Schwartz (1945) gave a very complete description of the booming display of the Prairie Chicken. Typically its component parts consist of raising the pinnae vertically above the head, rapid stomping of the feet while standing still or running forward, raising or lowering the head, inflating the oesophagus so that the orange "booming sacs" are distended; a rapid opening of the tail feathers, which produces an audible click, slight lowering of the wings but retaining the carpal joint within the covering flank feathers, and uttering three "booming" notes which sound like blowing over the open neck of a large bottle. This call may carry for several kilometres. The homologous tail rattling display of the Sharp-tailed Grouse consists of holding the horizontal body high off the ground on extended legs, lowering the head, raising the feathers dorsal to the cervical apteria, exposing the purple booming sacs, extending the wings from the body sometimes at full stretch with a downward curve of the primaries, erecting the tail at least vertically and often tilted slightly forward, spreading each side of the tail alternately at high speed making a loud rattling sound, and uttering a note that sounds like a cork being withdrawn from a bottle or a shrill "chilk" or hoarse "cha" call.

A second display homologous with the "booming" segment of the Prairie Chicken display is called "cooing". The bird stands still, extending the neck forward and slightly upward, inflating the oesophagus and hence distending the purple cervical apteria, bowing the neck slightly downward and uttering a loud cooing note, usually keeping the carpal joint of the wing covered by the flank feathers (Lumsden1965*).

Those hybrids that most nearly resembled Prairie Chickens produced the booming display, sometimes typically but frequently with three weak notes and some omitted the third note. One hybrid boomed with a single note, drooping his wings as he uttered and spread his tail with an audible hissing sound.

Another hybrid cooed instead of booming: he held his wings slightly open but flicked them fully open, spreading his primaries while vibrating his tail without the volume of rattling in a pure Sharp-tailed Grouse. He produced an audible click with his tail at the end of this performance. Another hybrid, when cooing, uttered a double note. A Prairie Chicken-like hybrid made a rustling sound with his tail when booming and extended his wings slightly, retracting them at the third booming note. A Sharp-tailed Grouse-like hybrid produced three wheezy notes in his tail-rattling display. There was much confusing variation in the displays of hybrids and individuals were not as consistent in the component parts of their display as the two parent species.

Colours of Booming Sacs and Feet

The resonance of the booming and cooing calls is produced by inflation of the oesophagus that distends the coloured skin of the cervical apteria. In Prairie Chickens, these booming sacs, or timpani as they are sometimes called, are orange in colour with a narrow pink rim adjacent to the feathers. In Northern Sharp-tailed Grouse (*T. p. phasianellus*), the booming saks are smaller than in Prairie Chickens and are purple. At the height of the mating season they may be almost as dark as blueberries. Those of the Prairie Sharp-tailed Grouse (*T. p. campestris*) are much paler and are pinkish-purple in colour. The timpani of hybrids are very variable in colour. Those in the middle of the cline between the species may have a muddy violet edge with one to three small dull orange patches. Others may have a reduced orange-yellow patch with an enlarged dusky pink rim.

Prairie Chickens have dusky orange toes during the breeding season. In Sharp-tailed Grouse, they are grey. Hybrids varied from orange through yellowish orange, to yellowish-grey to grey coloured feet. All these Prairie Grouse seem to molt the pectinations of their toes in mid-April and the displaying males, toward the end of the display period, show considerable wear on their nails.

Discussion

The hybrid indices summarized in Tables 1-4, 6-7 suggested that the proportion of hybrids in the Manitoulin population was between 32% and 60%. Certain features of the pinnae and tail suggest that hybridization may have been more extensive than this. Unexpected in the morphology of the Manitoulin Prairie Grouse was the relatively short pinnae of the population. That none reached the mean length of 77.7 mm of Wisconsin Prairie Chickens was a surprise. The longest measured 75 mm. Genetically, the Manitoulin birds are descended from the Wisconsin stock, 20 to 30 years before this study began and several hundred kilometres removed. This strongly suggests that hybridization on the island was more extensive than indicated by the other hybrid indices. The line pattern on the tail of Northern Sharp-tailed Grouse was missing in a proportion 4 or 5 times that expected of Sharp-tailed-type Manitoulin Grouse. Perhaps it is not unexpected that 93% of those classified as hybrids should lack the line pattern. This feature is a secondary sexual character that may be more readily modified by hybridization than primary characters.

The steep graduation of the tail occurs in both sexes of Sharp-tailed Grouse and is therefore not a secondary sexual character. The trends in measurements do not completely conform to the pattern shown in other characters. One might expect that in Class 5 (Table 4) in 1964–1970 the influence of Prairie Sharp-tail genes might produce a more steeply graduated tail. Perhaps this unusual tail structure is not sufficiently integrated in the gene matrix of the species to resist the more conventional square tail of the Prairie Chicken genes in hybrids.

Tables 2-4, 6 and 7 showed a number of trends. In the first period, 1949–1959, there was a tendency for hybrids to cluster toward Class 1 and 2 on the Prairie Chicken end of the scale. By the third period, 1964–1970, the clustering was toward Class 4 and 5 or the Sharp-tailed Grouse end of the scale.

In Class 1 and 2 there was a strong tendency for the number of specimens to decline in each period while the number in Class 4 and 5 showed an increase. The latter is probably because Prairie Sharp-tailed Grouse had completely colonized the island and were contributing their genes to the mix. Observations indicated that the alpha males at Sheguiandah and at Billings lek in 1966 were probably Prairie Sharp-tailed Grouse (Lumsden 2005).

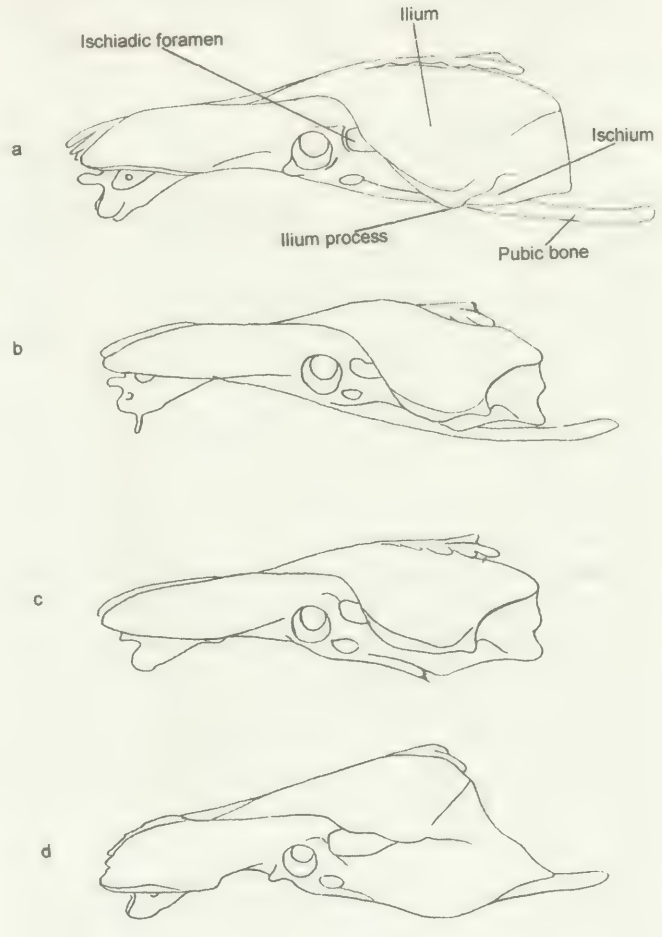

FIGURE 5. Ilium process of (a) Greater Praire Chicken (b) and (c) Heath Hen and (d) Northern Sharp-tailed Grouse.

The speed with which change took place in the morphology of the Manitoulin population over time was perhaps largely due to the fact that "Prairie" Grouse are lek species. The particular bird that succeeds in becoming the alpha male in the hierarchy of dominance on a lek would consummate most of the matings. His genes would dominate in the subsequent year class. The absence of male Prairie Chickens on the Airport lek in 1962 and the presence of 10 male Prairie Sharp-tailed Grouse would have had a profound effect on the 1962-1963 year class. It is perhaps not surprising that Guild (1997*) saw 50 Sharp-tailed Grouse there on 19 April 1997. J. Iron (personal communication) saw 75-100 on 15 April 2000, 30 on 12 April 2003 and 60 Sharp-tailed Grouse there on 11 April 2004. Those observers made no mention of Prairie Chickens or hybrids. Being skilled naturalists, they are unlikely to have missed them.

Note: The extinct Heath Hen (*Tympanuchus c. cupido*) is of interest in that its ilium process does not project as far as that of the Greater Prairie Chicken (*Tym-*

panuchus c. pinnatus) (Figure 4). The two specimens I have examined would be placed in Class 2 and 3 of Table 7. Gutiérrez et al. (2000) judged the Heath Hen to be a species level taxon. The structure of the ilium may support that judgement.

Acknowledgments

I thank L. L Snyder, former Curator of Birds at the Royal Ontario Museum, for working space and encouragement. For the loan of specimens I thank J. J. Hickey, Department of Wildlife Ecology, Madison Wisconsin; R. W. Storer, University of Michigan Museum, Ann Arbor; D. D Ripley, Peabody Museum, Yale; H. Friedman, U.S. National Museum, Washington, D.C.; and the Field Museum, Chicago.

Many individuals supplied information and specimens. My particular thanks go to W. Ritching, B. Smith, H. McQuarrie, H. Bailey and J. Budd. I thank F. and F. N. Hamerstrom, Wisconsin Department of Natural Resources, and A. Ammann, Michigan Department of National Resources, for valuable discussions and unpublished data. I received help collecting Prairie Chicken specimens from J. Horak, G. Smart, R. D. Buckingham, K. Mentzel, C. Baker, N. D. Patrick, L. Bluss, J. B. Dawson, B. Stephenson, R. Hepburn and many field staff from the Ontario Ministry of Natural Resources.

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Received 15 April 2005
Accepted 15 September 2005

Response of Pale Swallow-wort, *Vincetoxicum rossicum*, following Aboveground Tissue Loss: Implications for the Timing of Mechanical Control

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McKague, Curtis I., and Naomi Cappuccino. 2005. Response of Pale Swallow-wort, *Vincetoxicum rossicum*, following aboveground tissue loss: implications for the timing of mechanical control. Canadian Field-Naturalist 119(4): 525-531.

The growth and reproduction of Pale Swallow-wort, *Vincetoxicum rossicum*, were investigated following differentially timed above-ground tissue loss by clipping throughout the growing season in Ottawa, Canada. If clipping occurred early in the growing season (before June), mature plants were able to compensate in height but not in biomass or reproductive output when compared to uncut controls. This compensation in height did not seem to come at the expense of below-ground storage tissue; there was no significant difference in root mass among the control and treatment conditions. Final plant height, mass, and reproduction declined as plants were cut later in the season. Pale Swallow-wort seedlings clipped before June were able to compensate in height when compared to uncut controls. Unlike mature plants, this compensation in height did come at the expense of root mass. As the clipping treatment was performed later into the growing season, both final plant height and shoot mass decreased, while root mass increased. The best time for controlling the population spread of Pale Swallow-wort using a single cutting treatment was on or near 26 June. Plants cut earlier than this date were able resprout and produce seeds; those cut after had already produced seeds that appeared viable and may be able to germinate if the cut stems were left in the field. When a single cutting or mowing treatment is to be employed for controlling Pale Swallow-wort, we recommend cutting after the first fruits are produced but before they are fully developed.

Key Words: Pale Swallow-wort, Dog-strangling Vine, *Vincetoxicum rossicum*, *Cynanchum rossicum*, mechanical control, invasive plants, Ottawa.

Pale Swallow-wort, *Vincetoxicum rossicum* Kleo. Barb. (Asclepiadaceae; synonym *Cynanchum rossicum*), also known as Dog-strangling Vine, is an introduced plant species that is becoming an increasingly problematic weed of natural areas in the northeastern United States and Ontario. Native to Ukraine and Russia, Pale Swallow-wort was introduced into North America in the late 1800s (Sheeley and Raynal 1996). Pale Swallow-wort has been documented across southern Ontario from Toronto to Ottawa (DiTommaso et al. 2005), and has recently spread across the Ottawa River into the Outaouais region of Quebec and has been located in Montreal (DiTommaso et al. 2005). Within the United States, Pale Swallow-wort is widely distributed within New York State, and has also been documented in Connecticut, Indiana, Massachusetts, Michigan, New Hampshire, New Jersey, and Pennsylvania (DiTommaso et al. 2005).

Pale Swallow-wort (Figure 1) is a perennial herbaceous vine, with stem lengths of mature individuals ranging from 60-250 cm (DiTommaso et al. 2005). Stems are often intertwined within dense patches while individual plants climb upon other vegetation for structural support. Leaves are ovate and acute at the tip and are opposite in arrangement (DiTommaso et al. 2005). Flowers are pink to red in coloration, 5-7 mm in diameter, and have five fleshy petals arranged in a star configuration. Fruits, often arranged in pairs, are slender follicles 4-7 cm long (St. Denis and Cappuccino 2004; DiTommaso et al. 2005). In late summer, follicles release wind-dispersed comose seeds which are 3-5 mm in length (DiTommaso et al. 2005).

Pale Swallow-wort is capable of thriving under various environmental conditions and has been documented in numerous habitat types, including lawns, gardens, old fields, disturbed areas, and along both coniferous and deciduous forest edges as well as within their understoreys (Sheeley and Raynal 1996; DiTommaso et al. 2005). Pale Swallow-wort thrives on limestone-based soils and is invading globally rare alvar habitats on the limestone plains of northern New York State (DiTommaso et al. 2005 and personal observation). Once established, populations of Pale Swallow-wort grow densely and spread aggressively, often eliminating native plants (Sheeley and Raynal 1996; Christensen 1998). Competitive displacement of native plant species by Pale Swallow-wort may have negative consequences for local faunal. Ernst and Cappuccino (2005) found that diversity and abundance of both stem- and ground-dwelling arthropod species were substantially lower in patches of Pale Swallow-wort than in patches of native old-field plant species (*Asclepias syriaca*, *Solidago altissima*, and mixed graminoids). Pale Swallow-wort is also detrimental to the Monarch butterfly (*Danaus plexippus*) which has been observed ovipositing on it rather than on milkweed (*Asclepias syriaca*),

its usual plant host, resulting in larval death (Mattila and Otis 2003).

Although Pale Swallow-wort is not listed in any federal or provincial/state weed or seed acts in Canada or the United States (DiTommaso et al. 2005), it is recognized as a noxious weed and control programs are initiated at the municipal level. Attempting to control the spread of Pale Swallow-wort is a difficult task. It is self-compatible, so a single propagule can initiate a new infestation (St. Denis and Cappuccino 2004). Individual plants produce large numbers of viable seeds, which require neither dormancy nor stratification (Christensen 1998). Seedling survivorship is very high, ranging from 70 to 100% (Ladd and Cappuccino, in press). Seeds are polyembryonic (Sheeley and Raynal 1996; St. Denis and Cappuccino 2004), producing multiple seedlings about half the time (Cappuccino et al. 2002).

Options for controlling Swallow-wort are limited. Herbicides such as glyphosate are moderately effective; however, several applications are needed (Christensen 1998; Lawlor and Raynal 2002). A growing number of communities are banning herbicides due to their toxicity to humans and non-target organisms (DiTomaso 1997); in these places, manual means of controlling Swallow-wort are necessary. Repeated mowing can be an effective way to diminish the seed crop, but it does not kill the plants which resprout from buds at the root crown (Christensen 1998; DiTommaso et al. 2005). Moreover, mowing may not be feasible where equipment and labour are limiting. Mowing areas that are not monotypic stands of Pale Swallow-wort may alter the structure of the native plant community, which may be detrimental to insect populations (DiTomaso 1997).

For smaller infestations of Pale Swallow-wort, selectively clipping individuals may be a more ecologically effective solution. If available resources dictate that only a single cut is to be made, the timing of that cut is critical in determining whether seed production will be prevented. In general, plants clipped early in the growing season are more likely to compensate in growth and/or reproduction (Maschinski and Whitham 1989; Bergelson and Crawley 1992; Mutikainen et al. 1994; Bergelson et al. 1996; Lennartsson et al. 1998). If clipping occurs later in the growing season, plants often have insufficient time for compensatory growth. A late-season cut may thus seem preferable; however, seeds already produced by the plant may be viable if the cut stems are left at the site or scattered by a mower.

The present study was performed to better understand the growth and reproductive responses of Pale Swallow-wort following aboveground tissue loss by clipping at different times throughout the growing season. From this increased understanding in Pale Swallow-wort biology, we hope that ecologically friendly and effective control methods may be used to slow the population growth of this species, thereby minimizing its deleterious effects on natural habitats.

Study Area and Methods

Response of mature plants to differentially timed aboveground tissue loss

This experiment was performed in an old field/forest edge habitat in Hog's Back Park, Ottawa, Ontario (45°22.45'N, 75°41.65'W), from May-August 2003. In mid-May, 150 individual plants of *Vincetoxicum rossicum* with initial heights of 30.2 ± 0.2 cm (mean ± SE) were measured and randomly assigned to one of five differentially timed clipping treatments, or to the uncut control condition. Initially, 25 plants were assigned to each treatment; however, some plants were lost during the course of this experiment due to damage by humans or other animals.

Beginning on 29 May, all plant heights were measured and flower or fruit formation was noted. The first clipping treatment was performed this day. Clipping involved cutting the plants at ground level. Cut plants were dried for three days in a drying oven at 60°C and weighed. Subsequent clipping treatments were performed every two weeks until the final clipping treatment on 24 July. Plant heights were recorded on each clipping date and again on 7 and 21 August. Above- and below-ground tissues for all plants were harvested on 21 August and dried for three days in the drying oven. Roots and shoots were weighed separately for each plant. Any seeds that were produced were counted.

Response of seedlings to differentially timed aboveground tissue loss

A similar experiment was performed in an enclosed old field setting on Carleton University property in Ottawa, Ontario (45°23.023'N, 75°41.553'W) from May-August 2003. During April 2003, *V. rossicum* plants were grown from seed in a greenhouse at Carleton University. In mid-May, 150 of these seedlings with initial heights of 18.0 ± 0.4 cm (mean ± SE) were transplanted into the old field after a two-week outdoor acclimatization period. Seedlings were randomly assigned to the same clipping treatments described above for mature plants.

Statistical Analyses

All statistical analyses were performed using SPSS 11.5 for Windows (standard base version). Pre-treatment heights for both adult plants and seedlings in the different treatments were compared using one-way ANOVAs. Because the assumptions of parametric statistics were not met, Kruskal-Wallis tests were used to investigate among-treatment differences in final heights, shoot mass, and root mass for both adult plants and seedlings, as well as the seed output of adult plants. When a statistically significant difference was observed among treatments, a Games-Howell post-hoc test, which allows for unequal variance and unequal sample size, was performed to determine which treatments differed from one another (Games and Howell 1976).

Results

Response of mature plants to differentially timed above-ground tissue loss

Pre-treatment heights did not differ significantly among the treatments (ANOVA, $F_{5,144} = 1.754$, $P = 0.126$). The time of the growing season when plants were cut had a significant effect on final height (Kruskal-Wallis, $H = 85.786$ df = 5, $P < 0.001$). The Games-Howell post-hoc test revealed that plants that were cut on 29 May were able to compensate in height; they were not significantly different in height from the uncut controls (Figure 2). The final heights of plants cut on 29 May, 12 and 26 June were not significantly different from one another but they did differ from both 10 and 24 July treatments. The 10 and 24 July treatment plants were not significantly different from one another but they did differ significantly from all other treatment groups in the experiment including uncut controls.

The timing of the cut did not have a significant effect on root mass (Figure 3, Kruskal-Wallis, $H = 6.123$ df = 5, $P = 0.294$), while shoot mass did differ significantly among treatments (Kruskal-Wallis, $H = 96.952$ df = 5, $P < 0.001$). The Games-Howell post-hoc test revealed that none of the experimentally clipped plant groups were able to compensate in shoot mass; all clipping treatments weighed significantly less than the uncut control. Plants cut on 29 May, 12 and 26 June were not significantly different from one another but they

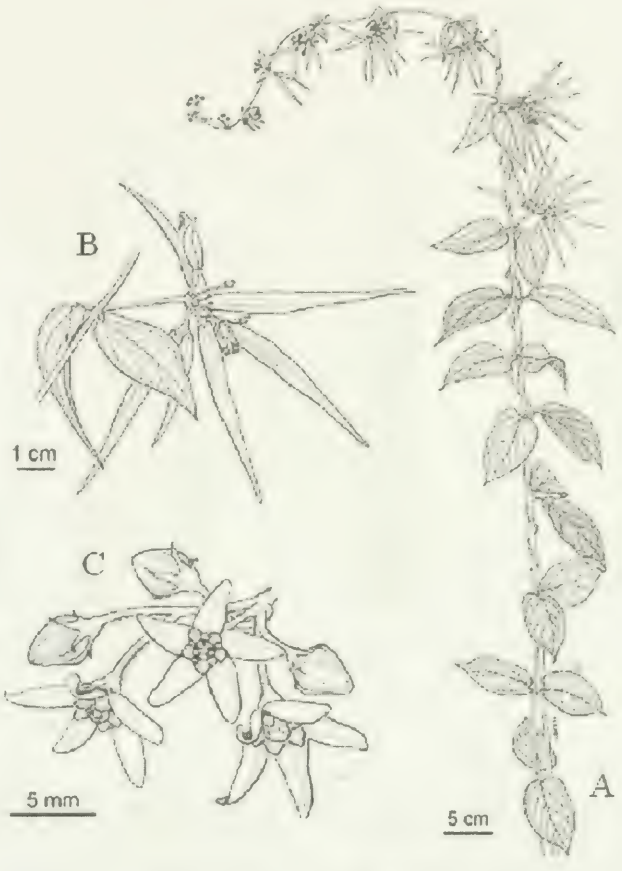

Figure 1. Pale Swallow-wort, *Vincetoxicum rossicum*. A. An individual plant characteristically climbing substrate for structural support; B. Leaves and fruits; C. Inflorescences showing buds and mature flowers (Figure borrowed from DiTommaso et al. 2005, with permission from the authors and *Canadian Journal of Plant Science*).

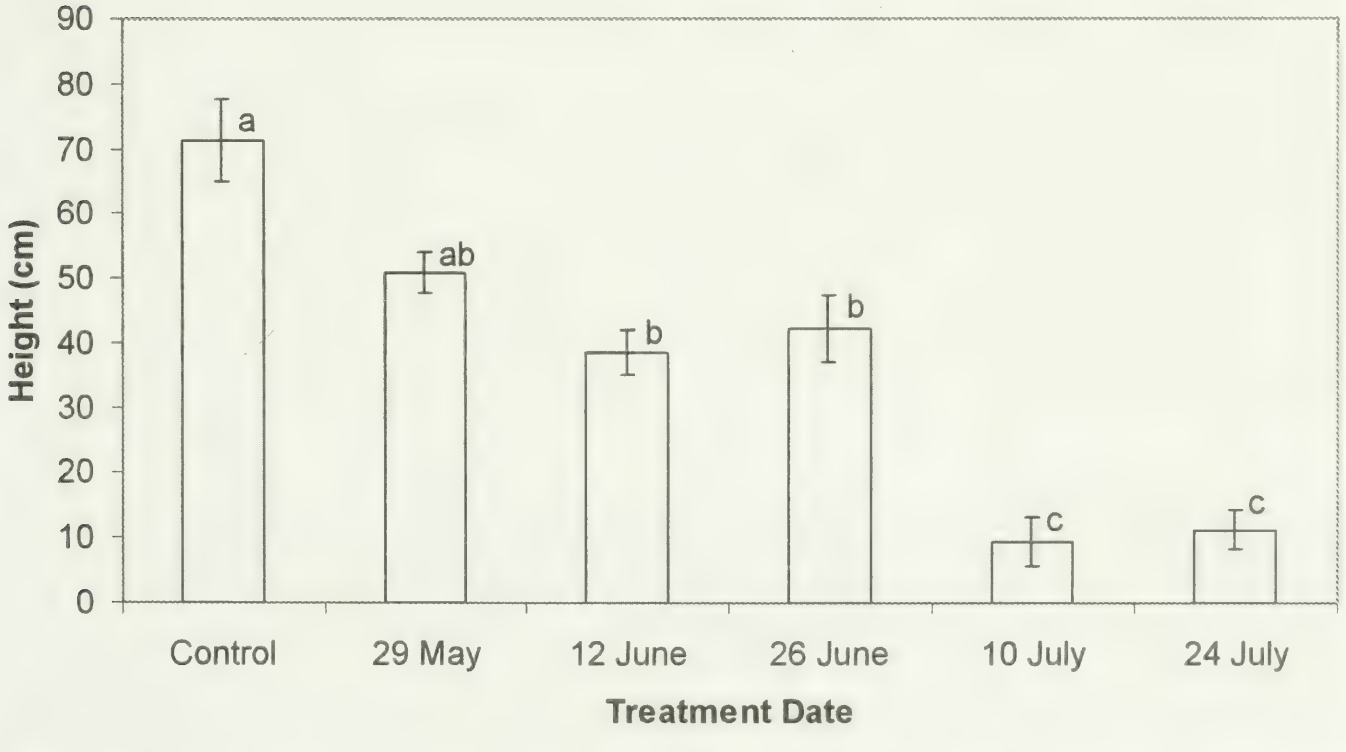

Figure 2. Final height of mature Pale Swallow-wort plants clipped on various dates. Values are means ± SE. Clipping date had a significant effect on plant mean height (Kruskal-Wallis test, $H = 85.786$, df = 5, $P < 0.001$). Ranked means that were significantly different ($P < 0.05$) according to Games and Howell's (1976) multiple comparisons test are assigned different letters.

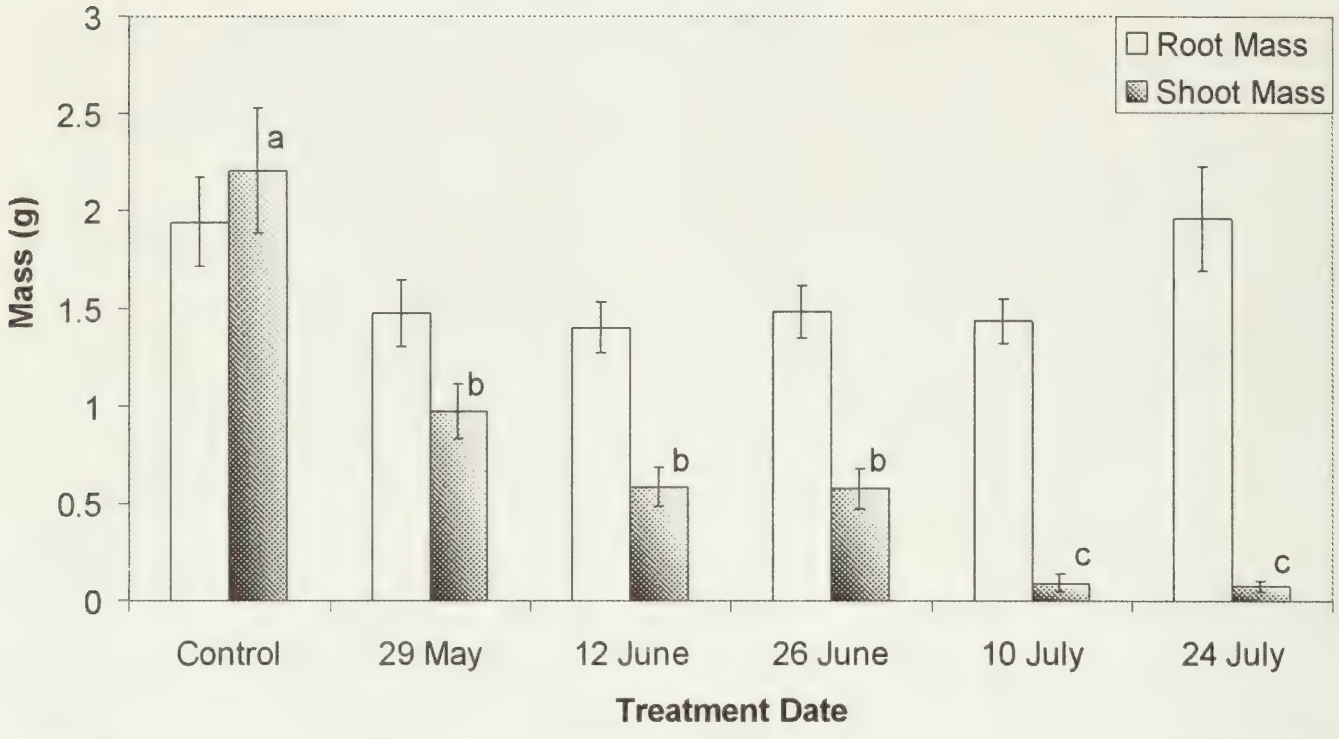

FIGURE 3. Final root and shoot mass of mature Pale Swallow-wort plants clipped on various dates. Values are means ± SE. Clipping date had a significant effect on mean shoot mass (Kruskal-Wallis test, H = 96.952, df = 5, P < 0.001) but there was no difference in mean root mass among treatments (Kruskal-Wallis test, H = 6.123, df = 5, P = 0.294). Ranked means that were significantly different (P < 0.05) according to Games and Howell's (1976) multiple comparisons test are assigned different letters.

did differ from both 10 and 24 July treatments. The 10 and 24 July treatment plants were not significantly different from one another but they did differ significantly from all other treatment groups.

Seed production was greatly affected by clipping treatments (Table 1). Experimentally cut plants showed a significant decline in their reproductive output in comparison to uncut controls (Kruskal-Wallis, H = 50.107 df = 5, P < 0.001). The Games-Howell post-hoc test revealed that the clipping treatments were not significantly different from one another. No fruit production was observed until 26 June, and those plants that produced seeds despite having been clipped (29 May and 12 June cutting treatments) did so by 24 July and 7 August, respectively. Plants cut on or after 26 June failed to produce any seeds.

Response of seedlings to differentially timed aboveground tissue loss

Seedlings in the six treatments did not differ significantly in initial height (ANOVA, $F_{5,144} = 0.480$, P = 0.791). The timing of clipping had a significant effect on their final height (Kruskal-Wallis, H = 66.931 df = 5, P < 0.001). The Games-Howell post-hoc test revealed that plants that were cut on 30 May were able to compensate in height as they were not significantly different in height from the uncut controls (Figure 4). Plants cut on 13 and 27 June, and 11 and 25 July were significantly smaller at the end of the season than those in the control treatment and the 30 May treatment.

The time of the growing season when seedlings were cut had a significant effect on root mass (Figure 5, Kruskal-Wallis, H = 21.013 df = 5, P = 0.001).

TABLE 1. Seed production of mature Pale Swallow-wort plants clipped on various dates. Number of seeds per plant are group means with SE in parentheses. Clipping date had a significant effect on reproductive output (Kruskal-Wallis test, H = 50.107, df = 5, P < 0.001). Treatments with significantly different (P < 0.05) seed production according to Games and Howell's (1976) multiple comparisons test are assigned different letters.

Treatment Group	n	Proportion producing seed	Number of seeds per plant
Control	27	0.56	47.2 (13.2)[a]
29 May	24	0.13	5.4 (3.3)[b]
12 June	22	0.14	2.3 (1.4)[b]
26 June	23	0.00	0.0 (0.0)[b]
10 July	24	0.00	0.0 (0.0)[b]
24 July	24	0.00	0.0 (0.0)[b]

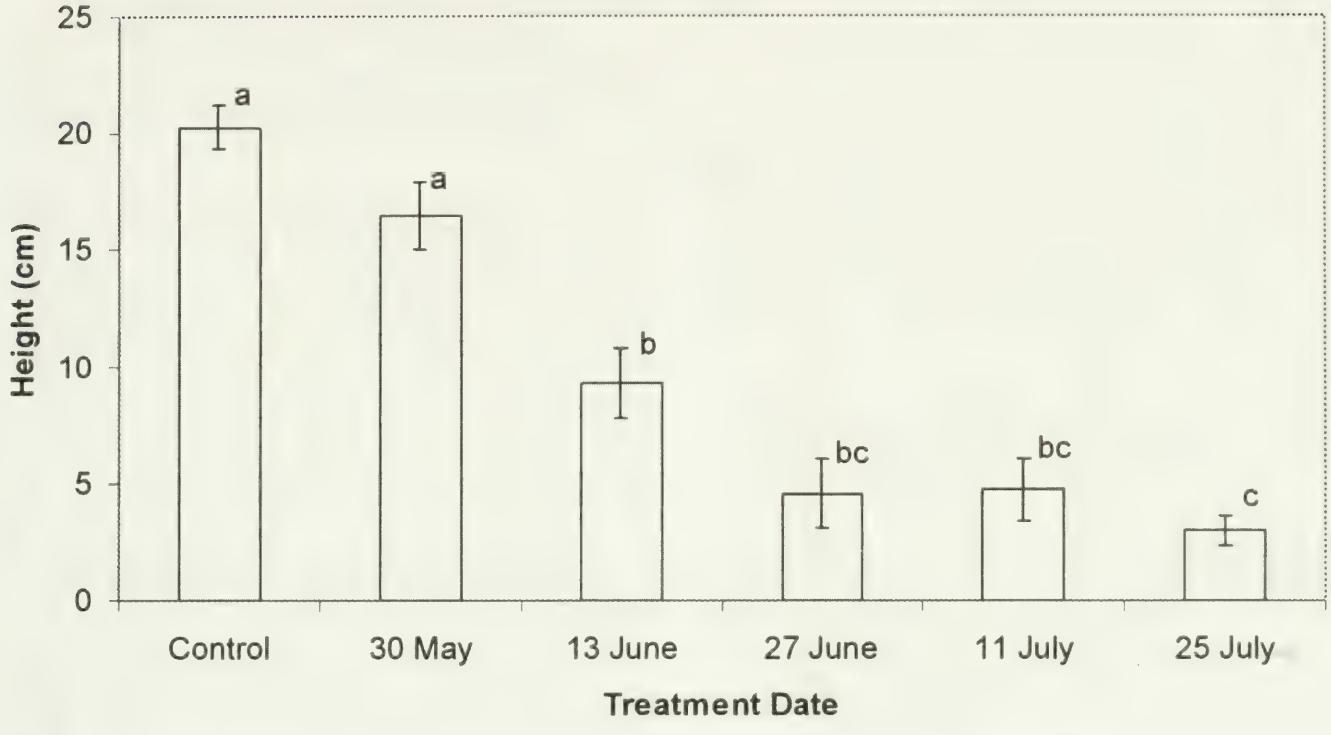

FIGURE 4. Final height of Pale Swallow-wort seedlings clipped on various dates. Values are means ± SE. Clipping date had a significant effect on plant mean height (Kruskal-Wallis test, H = 66.931, df =5, P < 0.001). Ranked means that were significantly different (P < 0.05) according to Games and Howell's (1976) multiple comparisons test are assigned different letters.

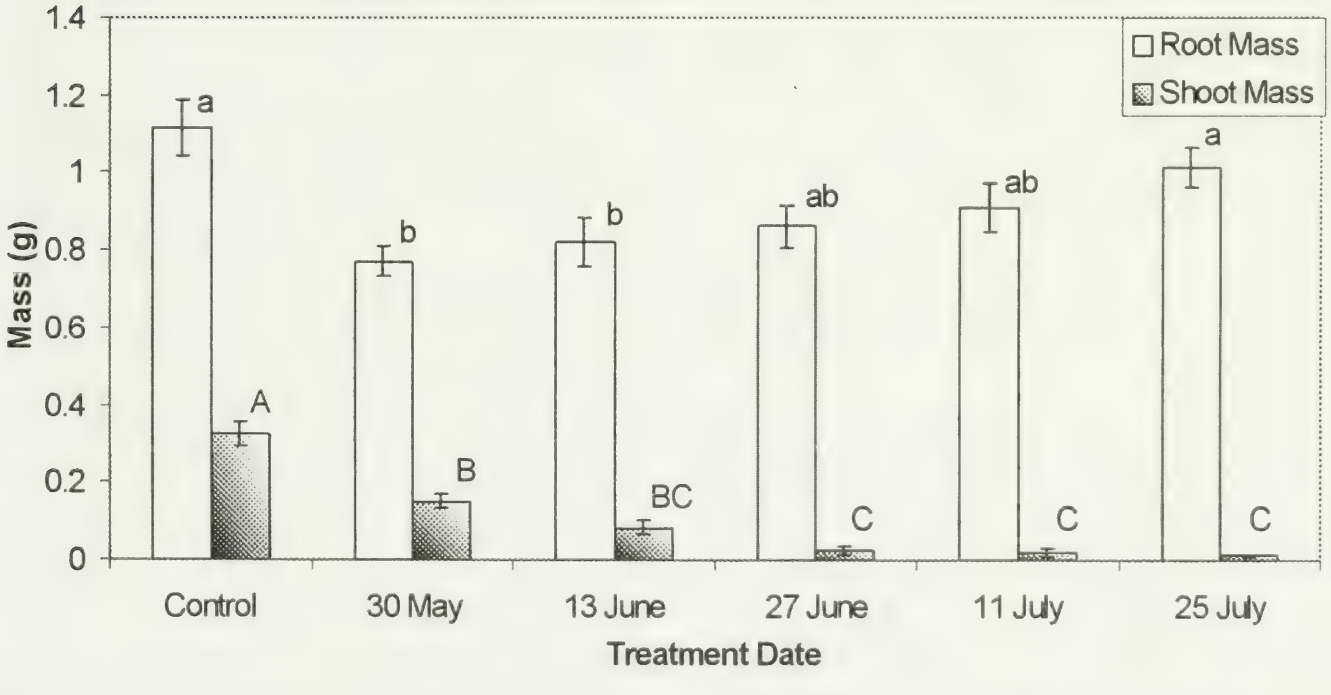

FIGURE 5. Final root and shoot mass of Pale Swallow-wort seedlings clipped on various dates. Values are means ± SE. Clipping date had a significant effect on mean shoot mass (Kruskal-Wallis test, H = 68.644, df = 5, P < 0.001) and on mean root mass (Kruskal- Wallis test, H = 21.013, df = 5, P = 0.001). Ranked means of shoot mass that were significantly different (P < 0.05) according to Games and Howell's (1976) multiple comparisons test are assigned different uppercase letters while ranked means of root mass that were significantly different (P < 0.05) according to Games and Howell's (1976) multiple comparisons test are assigned different lowercase letters.

Root mass was lowest for the 30 May treatment group and scores tended to increase in value as plants were cut later in the season. Final shoot mass also differed significantly among treatment groups (Figure 5, Kruskal-Wallis, $H = 68.644$ $df = 5$, $P < 0.001$). The Games-Howell post-hoc test revealed that none of the experimentally clipped plant groups were able to compensate in shoot mass; all clipping treatments differed significantly from the controls. No seedlings produced flowers or seeds.

Discussion

When the stems of Pale Swallow-wort are cut during the growing season, new shoots emerge from buds at the root crown. In the present study, in which primary shoots were cut at two-week intervals throughout the growing season, Pale Swallow-wort plants resprouted, but were not able to compensate fully for tissue loss. As we expected from the results of previous studies on other plant species (e.g., Maschinski and Whitham 1989; Bergelson and Crawley 1992; Mutikainen et al. 1994; Bergelson et al. 1996; Lennartsson et al. 1998), the ability of Pale Swallow-wort to partially compensate for tissue loss declined as plants were clipped progressively later in the growing season. Although plants cut on 29-30 May appeared to compensate in height, by the end of the growing season the new shoots had not attained the same biomass as the primary shoots produced by the uncut controls.

While the root mass of mature Pale Swallow-wort plants showed no significant effect of above-ground tissue removal, the clipping treatment significantly diminished the root mass of the seedlings. Seedlings lack the extensive root system of the mature plants, and their partial compensation in height and biomass seemed to come at the expense of their roots. All seedlings in our experiment survived until the end of August. However, in a summer with less rainfall than 2003, the reallocation of resources from root to shoot following clipping could leave the seedlings with underdeveloped root systems incapable of sustaining the plant through a drought (e.g., Bilbrough and Richards 1993; Perkins and Owens 2003).

Mature control plants allocated nearly half their biomass to roots, a high proportion for mid- to late-successional species (Parrish and Bazzaz 1982). The high root:shoot ratio is partly explained by the weakness of the stem of this vine-forming plant; stems that have not twined around neighbouring vegetation generally cannot support the weight of the fruits and flop to the ground once fruit production is underway. However, the plant also possesses an extensive fibrous root system with a thick, woody rootstock, which likely contributes to its apparent ability to outcompete native vegetation and persist for decades (Sheeley and Raynal 1996). Seedling root:shoot ratios were even higher; control seedlings invested over three times more tissue into root mass versus shoot mass. The seedlings appeared to be developing below-ground storage tissue in preparation for future growing seasons. This may explain the slow maturation of Pale Swallow-wort; in a separate experiment, individuals planted as seeds four years ago have yet to flower (N. Cappuccino, unpublished data).

Seed production was reduced dramatically by clipping. Clipping on or after 26 June halted seed production entirely. Clipping earlier in the season was insufficient to completely control reproductive output; over 10% of the plants clipped on 29 May and 12 June produced seeds. Fruits were first observed on 26 June in the controls and the three treatments that had not previously been cut. A single clipping treatment during this period of the growing season would be most effective because the fruits on this date contained only immature seeds that would be unable to germinate if left in the field following clipping. Plants clipped on or after 10 July also failed to produce seeds following clipping, but prior to clipping, their fruits contained seeds that appeared to be mature (they were filled and darkening in preparation for release). Although our data suggest that clipping in late June would be most effective, the timing of fruit production in other years and at other sites may vary. We recommend that plants be monitored for fruit formation and that cutting take place when the first fruits are formed but not fully developed.

Mechanical control by clipping can be a successful method for controlling localized patches of Pale Swallow-wort that are threatening native species. However, the ability of the plant to regrow following above-ground tissue loss both underscores the need for a more sustainable means of controlling this invasive weed, such as biological control, and argues against introducing a leaf-chewing herbivore as the sole control agent. Adequate control of target plants following the introduction of a single herbivore is the exception rather than the rule (Julien 1989) and success is often achieved only after introduction of several herbivores (Denoth et al. 2002) that damage the plant in complementary ways (James et al. 1992). Damaging the target plant in complementary ways can also be achieved through integrated weed management, for example, by combining mechanical control with biological control (Paynter and Flanagan 2004). Integrated weed management is increasingly being viewed as the most effective strategy for controlling invasive plants in natural areas (Buckley et al. 2004) and is likely our best hope for controlling Pale Swallow-wort.

Acknowledgments

This research was funded by the Natural Sciences and Engineering Research Council of Canada (Undergraduate Student Research Award to CIM and Discovery Grant to NC). Permit for land access for this experiment was granted by Mike Muir of the National Capital Commission (NCC). The authors wish to thank

the two anonymous reviewers for their helpful critical reviews of this manuscript; David Carpenter for his assistance in the field; Ed Bruggink for caring for our seedlings; and a special thanks to Jack and Yvonne McKague for their eternal support.

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Received 6 July 2004
Accepted 7 December 2005

Differential Parental Care by Adult Mountain Plovers, *Charadrius montanus*

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Dinsmore, Stephen J., and Fritz L. Knopf. 2005. Differential parental care by adult Mountain Plovers, *Charadrius montanus*. Canadian Field-Naturalist 119(4): 532-536.

We studied chick survival of the Mountain Plover (*Charadrius montanus*) in Montana and found that chicks tended by females had higher survival rates than chicks tended by males, and that chick survival generally increased during the nesting season. Differences in chick survival were most pronounced early in the nesting season, and may be related to a larger sample of nests during this period. When compared to information about the nest survival of male- and female-tended plover nests, our chick data suggest a trade-off for adult plovers between the egg and chick phases of reproduction. Because Mountain Plover pairs have clutches at two nests at two different locations and show differential success between the sexes during the egg and chick phases, we offer that the Mountain Plover breeding system favours optimizing annual recruitment in a dynamic ecologic setting driven by annually unpredictable drought, grazing, and predation pressures.

Key Words: Mountain Plover, *Charadrius montanus*, chick survival, Montana

The Mountain Plover (*Charadrius montanus*) is an uncommon and locally distributed breeding bird of the western Great Plains (Knopf 1996). The mating system, described as rapid multi-clutch (Graul 1973), is unusual in birds and involves two clutches per pair per year, each clutch incubated by a single adult (Dinsmore 2001). The female is thought to lay a complete clutch for the male first, and then a second clutch at a different site for herself. The time between the start of incubation for each sex has not been well studied, but was 7-10 days for a small sample of nests in Montana (S. J. Dinsmore, personal observation). Because of this unusual mating system, Mountain Plovers offer an opportunity to investigate breeding strategy differences that may result from the sex of the tending adult. Earlier work with this species has shown differential nest survival by sex of the incubating adult during the incubation stage (Dinsmore et al. 2002); it is not known if these patterns extend through the chick phase to fledging.

Although many aspects of Mountain Plover biology have been well studied, there is little detailed information about the survival of plover chicks. Miller and Knopf (1993) estimated brood survival in northeastern Colorado and calculated a daily chick survival rate of 0.979; the probability that a chick survived the 36-day fledgling period was 0.466. Knopf and Rupert (1996) estimated the daily survival of plover chicks at 10-day age intervals and noted that survival generally increased with the age of the chick. Lukacs et al. (2004) estimated chick survival in east-central Colorado and found that daily survival was lowest immediately after hatch, and quickly increased within 4 days post-hatch. None of those studies addressed whether chick survival was related to the sex of the tending adult or varied seasonally. Here, we report estimates of daily chick survival of Mountain Plovers in Montana and attempt to understand how survival is influenced by the sex of the tending adult and day within the nesting season.

Methods

Study area

We studied Mountain Plovers in a 3000-km^2 area in southern Phillips County in north-central Montana (47°40'–47°55'N, 107°35'–108°30'W; Figure 1). The study area is bounded by the Missouri River to the south, the Sun Prairie and Content roads to the east, Beaver Creek to the north, and Highway 191 to the west. Approximately 2250 km^2 of the study area is in public ownership with the Bureau of Land Management (BLM, Malta Field Office) and the U. S. Fish and Wildlife Service (USFWS, Charles M. Russell National Wildlife Refuge). This area is a mixed-grass prairie with sagebrush (*Artemisia* spp.) flats bordering the southwestern edge of the Prairie Pothole Region (Knowles et al. 1982; Olson and Edge 1985; Dinsmore et al. 2002). All of our work took place on active Black-tailed Prairie-dog (*Cynomys ludovicianus*) colonies that are used preferentially by Mountain Plovers in Montana (Knowles et al. 1982; Knowles and Knowles 1984; Dinsmore 2001).

Capture and marking

During the 1999 nesting season, we fitted 28 nest-tending, adult Mountain Plovers with 3.0 g radio transmitters (Advanced Telemetry Systems, Isanti, Minnesota) to allow us to monitor the survival of chicks within broods. Adult plovers were captured 1-4 days

prior to hatching date with a walk-in trap placed over the nest. On capture, we collected a feather sample from each adult for gender determination (see Dinsmore et al. 2003). Radio transmitters were glued to the mantle feathers of the adult using an epoxy (Titan Corporation, Lynnwood, Washington). Most adult plovers carried the transmitters until their chick(s) fledged and all transmitters were shed when the birds moulted prior to their fall migration. Chicks were marked with a unique series of four UV stable Darvic coloured leg bands (A. C. Hughes, London) and an aluminum U.S. Geological Survey band to allow individual identification. There were no adult or chick mortalities or injuries attributable to capture or handling. The Colorado State University Animal Care and Use Committee approved the field methods used in this study (Protocol 98-134A-01).

Using information from egg floatation (Dinsmore et al. 2002), we knew the exact hatch date for eggs in each nest and typically monitored chick survival at 1-5 day intervals post-hatch. On each brood check, we located the adult bird using a hand-held Yagi antenna and observed the number of chicks and identity of each chick that was present. We ceased to monitor chicks when they fledged at an age of 33-36 days (see Knopf 1996).

Modeling chick survival

We modeled the daily survival of plover chicks using the nest survival model (Dinsmore et al. 2002) in Program MARK (White and Burnham 1999). This model is similar to the Kaplan-Meier model that is typically used for telemetry data (Pollock et al. 1989), except that it does not require that the exact failure date be known. In our study, plover broods were not checked daily, so losses of individual chicks could only be assigned to an interval. We used an estimate of 35 days as the fledging date, except in cases where we knew that the fledging date differed (but never by more than 2 days). In a few cases, the tending adult lost its transmitter. In those cases, we censored the data at the last known brood check.

In our analyses, we considered four models to explain variation in chick survival of Mountain Plovers: (1) a model with constant survival [$S(.)$], (2) a model where chick survival differed based on the sex of the tending adult [$S\ (sex)$], (3) model #2 plus an additive effect of a linear time trend [$S\ (sex + T)$], and (4) model #2 plus an additive effect of a quadratic time trend [$S\ (sex + TT)$]. The $S(.)$ model is akin to a Mayfield estimate and implied that chick survival was constant across the entire nesting season, irrespective of date or sex of the tending adult. The $S(sex)$ model implicitly allowed chick survival to differ based on the sex of the tending adult. We were uncertain whether this was an important influence on chick survival, but deemed it a relevant question based on significant differences in the incubation stage (Dinsmore et al. 2002). The $S(sex + T)$ and $S(sex + TT)$ models added seasonal variation in chick survival to the sex difference

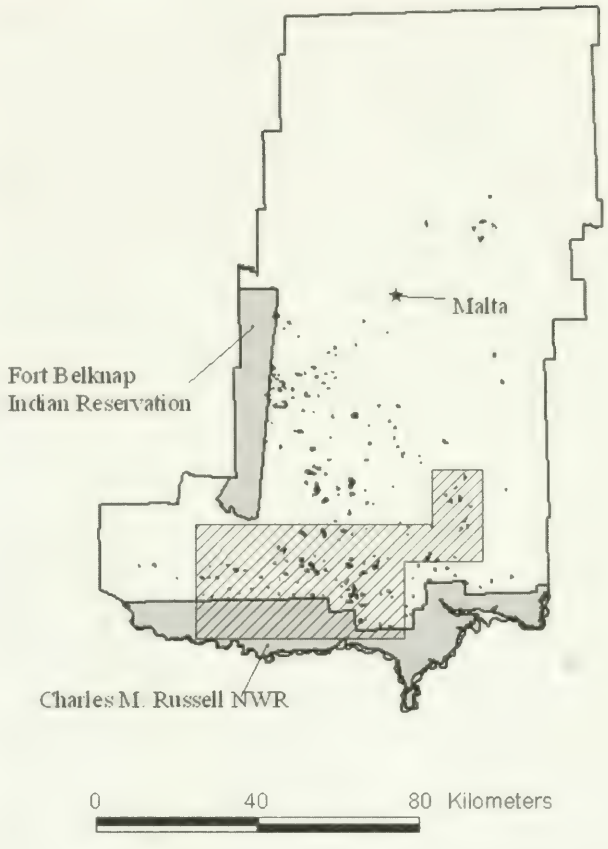

FIGURE 1. Map of Phillips County, Montana showing the distribution in 2000 of Black-tailed Prairie Dog colonies. The stippled regions show an Indian Reservation and National Wildlife Reserve. The hatched portion is the study area.

model. Based on our knowledge of plover biology, we suspected that chick survival might generally increase during the nesting season (Knopf and Rupert 1996), but were unsure whether this pattern might be linear or curvilinear.

We assessed the fit of the nest survival model to our chick survival data using a chi-square test of independence of the fates of chicks within broods as a function of brood size. We computed the expected values for the test statistic as the product of the number of broods in each clutch size (always two or three chicks) and the probability of observing that outcome. The latter probability was calculated as the product of survival (# surviving/total) and mortality (# dying/total) within each possible brood outcome. For example, the probability (Pr) of observing a brood of three chicks where only one survived is 3 * Pr(surviving)* Pr(dying)^2. We estimated over-dispersion as $\hat{c} = \frac{\chi^2}{\text{d.f.}}$ and made this adjustment in MARK.

We used the methodology of Burnham and Anderson (2002) to identify the best model(s) and make inferences about the factors influencing chick survival in plovers. We used Akaike's Information Criterion (AIC; Akaike 1973), corrected for possible small sample bias and over-dispersion (QAICc), to rank the set of candidate models. QAIC provides a means of objectively ranking a set of models and then selecting a "best ap-

proximating" model or models for inference (Burnham and Anderson 2002). We used QAICc values to compare the relative distances between the best approximating model and each competing model. Generally, models with QAICc values <2 have strong support while those with QAICc values >10 have little support (Burnham and Anderson 2002). Normalized Akaike weights (w_i) were also computed for each model to provide another measure of the relative importance of each model. Finally, we model averaged parameter estimates across all candidate models to obtain the "best" estimate(s) of chick survival (Burnham and Anderson 2002).

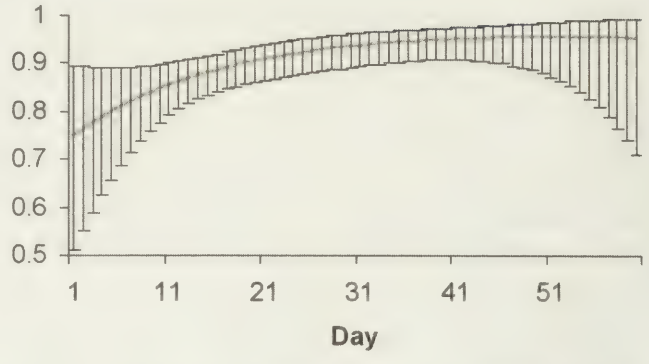

FIGURE 2. Daily survival rates (95% CI) for Mountain Plover chicks tended by a male parent in Montana, 1999. Day 1 corresponds to 11 June.

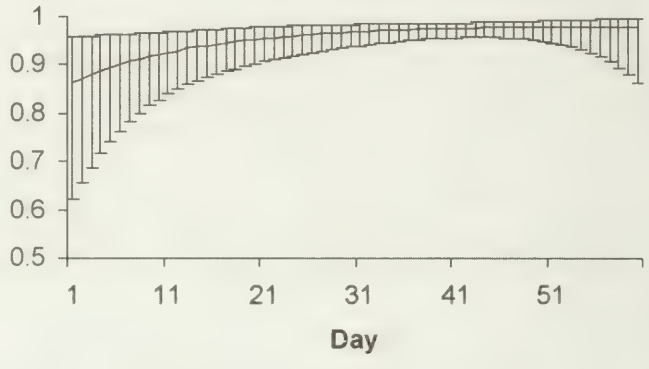

FIGURE 3. Daily survival rates (95% CI) for Mountain Plover chicks tended by a female parent in Montana, 1999. Day 1 corresponds to 11 June.

Results

We monitored 27 plover broods comprising 77 chicks (one adult plover died before its eggs hatched) during a 61-day period from 11 June to 10 August 1999. Two plovers (one male and one female) lost their transmitters in late June. Hatch dates varied, although we had slightly more broods early in the nesting season. The sample of tending adults was male-biased (18 males versus 9 females).

The nest survival model fit our chick survival data well ($\chi^2_6 = 7.08$, P = 0.31), and our estimate of overdispersion was $\hat{c} = 1.18$. We found good evidence for an effect of sex on brood survival (Table 1) with chicks in male-tended broods having lower daily survival ($\hat{\beta}_{male}$ = -0.78 on a logit scale, SE = 0.42, 95% CI was –1.60, 0.05). This effect was always negative in the top three models. In addition to the sex effect on chick survival, we found evidence that survival varied during the nesting season (Table 1). The best model ($w_i = 0.53$) had a quadratic time effect on survival, but a model with a linear effect on survival was nearly as good (QAICc = 0. 29, $w_i = 0.46$). Chick survival differed the most early in the nesting season, and after that was similar between male- and female-tended chicks. In both models, daily chick survival generally increased during the nesting season (Figures 2 and 3).

Discussion

Our results, while intriguing, should be interpreted with caution. By using information from all chicks within a brood, we risked violating the assumption of independent fates. It is important to note that violation of the independence assumption does not affect the parameter estimates, but does provide estimates of precision that are too small (Flint et al. 1995). Our test of independence of fates did not reveal any major violation of this assumption, although our sample size of broods was small. However, our observations and previous work with this species had shown that there was severe brood reduction within the first 1-2 weeks post-hatch (personal observation), but that many broods still fledged one or more chicks. Thus, attentiveness by the parent or some other factor was most likely the cause for chick losses, independent of the fates of other chicks in a brood.

Each component of the avian life cycle must be fully understood before inferences can be made regarding

TABLE 1. Summary of model selection results for the chick survival of Mountain Plovers in southern Phillips County, Montana, 1999. Models are ranked by ascending QAICc; w_i is the model weight and K is the number of parameters. Daily chick survival (S_i) was modeled to include no time effects (.), a linear time trend (T), a quadratic time trend (TT), and the effect of the gender of the tending adult (sex). QDeviance is computed as $-2[\log_e(L(\hat{\theta})) - 2\log_e(L_s(\hat{\theta}))]$ where $\hat{\theta}$ represents a maximum likelihood estimate whose log-likelihood is evaluated for the model in question $[L(\hat{\theta})]$ and for the saturated model $[L_s(\hat{\theta})]$.

Model	QDeviance	K	QAICc	QAICc	w_i
S (sex + TT)	206.68	4	214.73	0.00	0.53
S (sex + T)	208.99	3	215.02	0.29	0.46
S (sex)	218.10	2	222.12	7.38	0.01
S (.)	234.16	1	236.16	21.43	0.00

population processes. Information from some components (e.g., nest survival) is relatively easy to collect, but for others (e.g., chick and juvenile survival) it is more difficult, especially with precocial species like the Mountain Plover (see Lukacs et al. 2004). Collectively, such detailed information will present a clearer picture of the breeding cycle, and may hint at biological processes that influence success in each stage.

In an earlier study (Dinsmore et al. 2002), we showed that male-tended Mountain Plover nests had much higher survival during the incubation stage than did female-tended nests. We speculate that this results from some combination of temporal variation (male plovers are believed to tend the first nest), differential nest attentiveness, and the different physiological contributions of each sex (e.g., female plovers expend extra energy to produce eggs) early in the nesting cycle. Young Mountain Plovers are precocial (Knopf 1996) and typically leave the nest within hours of hatching, making it difficult to ask questions about possible differences in the survival of chicks in male- and female-tended broods.

Our results indicate that Mountain Plover chicks tended by the female have higher survival than those tended by the male, the opposite of what occurs during the incubation stage. Few birds share the same reproductive strategy as the Mountain Plover, and we were unable to find other published studies that addressed differential chick or brood survival as a result of the sex of the tending parent. A similar reproductive strategy has been well described for some species of North American quail (Burger et al. 1995; Pope and Crawford 2001), although these species differed from the Mountain Plover in adult sex ratio, nest initiation dates, and mean clutch size.

So what does this mean? Male-tended Mountain Plover nests are more successful than female-tended nests, which result in a greater number of broods with a male parent. But during the fledgling stage, female-tended chicks have greater survival, even though there are fewer female-tended broods (Dinsmore et al. 2002). The ultimate cause(s) for this apparent trade-off are unknown, although we can pose two possible explanations. For successful early nests, which tend to be male-tended (Dinsmore et al. 2002), the adult male may still be engaged in courtship activities with later nesting females. This could result in a drop in brood attentiveness, and a resulting decline in the survival of chicks in male-tended broods. The reverse pattern would not be expected for females because a female with a brood may lack the physiological capability to produce an additional clutch.

A second explanation, not necessarily independent of the first, attempts to reconcile the parenting conflicts of male plovers. Despite the asynchrony in nest initiation between the sexes, it appears that both members of the pair forage together during the incubation period (Graul 1973). In this scenario, the male may be in a conflict situation as he enters brood rearing while the female is still incubating. His attempts to maintain the pair bond might initially compromise his attentiveness to newly hatched chicks, resulting in lowered chick survival early in the brood stage. Larger differences in chick survival early in the nesting season may be a result of our larger sample of broods during this, the peak period of brood rearing.

The major evolutionary question that is still unanswered is, "What are the relative contributions of each sex to annual recruitment?" On the basis of this and other studies of the Mountain Plover, we conclude that male and female plovers attain similar rates of productivity with male plovers having higher nest survival and lower chick survival and female plovers showing a reverse pattern. These opposite patterns likely favor sustained productivity in the climatically unpredictable drought cycles of the Northern Great Plains. Putting the clutch of six eggs in two different nests at two different sites, each raised by a different adult, speaks to the flexibility in this breeding system that may have evolved in a highly unpredictable ecological landscape subject to major drought cycles, intensive grazing, and fluctuating predator populations.

Acknowledgments

We thank Fort Carson Military Reservation (U. S. Department of Defense), the U. S. Fish and Wildlife Service (Colorado Fish and Wildlife Management Assistance Office), the Biological Resources Division of the U. S. Geological Survey, the U. S. Bureau of Land Management (Malta Field Office, Montana), and the Denver Zoological Foundation for financial support. D. C. Ely, J. J. Grensten, and T. Hanks provided field assistance. G. C. White provided statistical advice. The manuscript benefited from careful reviews by A. J. Erskine and J. P. Goossen. This is contribution number WF207 of the Forest and Wildlife Research Center, Mississippi State University.

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Received 1 November 2004
Accepted 23 September 2005

Body Size Distribution and Frequency of Anthropogenic Injuries of Bluntnose Sixgill Sharks, *Hexanchus griseus*, at Flora Islets, British Columbia

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Dunbrack, Robert, and Robert Zielinski. 2005. Body size distribution and frequency of anthropogenic injuries of Bluntnose Sixgill Sharks, *Hexanchus griseus*, at Flora Islets, British Columbia. The Canadian Field-Naturalist 119(4): 537-540.

The Bluntnose Sixgill Shark (*Hexanchus griseus*) is a widely distributed demersal species whose population biology is poorly understood. Although *H. griseus* is normally found in deep continental slope waters, individuals from a population in the Strait of Georgia, British Columbia, make unexpected diurnal movements onto a shallow reef (Flora Islets) between June and August. This shallow water activity allowed *in situ* length measurements to be made on 35 free-swimming Bluntnose Sixgill Sharks using stereo videography. The measured sharks were all large juveniles and sub-adults, although smaller juveniles and pregnant females are known to occur in deeper adjacent waters. The restricted size distribution at Flora Islets may arise because small juveniles avoid contact with larger conspecifics and mating takes place offshore. All measured sharks were individually identified by unique scar patterns. In 13 of 35 sharks these scars were consistent with injuries expected from hooking and entanglement by commercial fishing gear.

Key Words: Sixgill Sharks, *Hexanchus griseus*, length-frequency distribution, anthropogenic injury, British Columbia.

The Bluntnose Sixgill Shark (*Hexanchus griseus*) is a demersal species found along the continental slopes of the Pacific, Atlantic, and Indian Oceans (Compagno 1984). *Hexanchus griseus* is one of the most widely distributed (Compagno 1984) and largest of fishes (length to at least 4.8 m; Castro 1983), and the highest trophic level predator throughout its range (Ebert 1994; Froese and Pauly 2005*), feeding on a variety of large prey items (Hart 1973; Compagno 1984; Ebert 1986, 1994). In British Columbia the Bluntnose Sixgill Shark occurs in the Strait of Georgia and the deep inlets of the mainland coast and the west coast of Vancouver Island (Hart 1973). There is little information on the population biology of *H. griseus*, despite its wide distribution, because it is not usually exploited commercially and scientific collecting has been limited due to the potential for adverse effects on local populations (Ebert 1986, 1994; Clark and Kristof 1990; Carey and Clark 1995). Although *H. griseus* is normally a deep water species, in the vicinity of Flora Islets in the Strait of Georgia, British Columbia, a number of Bluntnose Sixgill Sharks make diurnal movements into shallow water (20-40 m) between June and August. This activity provides a unique opportunity to collect quantitative behavioural and population data for *H. griseus* using simple and non-invasive underwater camera systems (Dunbrack and Zielinski 2003). In this paper a stereo video measurement technique is used to derive the body length-frequency relationship for Bluntnose Sixgill Sharks at Flora Islets.

Study Area

The study site is immediately adjacent to Flora Islets, a chain of three small islets southeast of Hornby Island in the Strait of Georgia (49°30.9'N, 124°34.5'W; Dunbrack and Zielinski 2003). The remote cameras used for length measurements were attached to the vertical face of a submerged rocky reef which parallels Flora Islets to the southwest 50 to 100 m offshore. Water depth at the base of the wall increases in a southeasterly direction from 30 m to over 200 m.

Methods

Length measurements were derived from analysis of paired images taken with two low light, black and white video cameras in waterproof housings. The cameras were mounted along a vertical pipe tied into the face of the reef wall with one camera 2.5 m above the other and both cameras facing down to the base of the wall which was 5 m below the lower camera and at a depth of 35 m. Individual cables from each camera ran to a surface float and terminated in waterproof connectors that could be plugged into leads on a surface vessel for recording. Stereo video length measurements of a 213 cm pipe, replicated in various parts of the cameras' visual fields, had a mean error of 2% (maximum error 4.9%). A detailed description of the stereo measurement system is given in Dunbrack (*in press*).

Individual sharks could be identified by distinctive lateral scar patterns; however, as a shark swam below the cameras, only its right or left side was visible. To

ensure that individual sharks were included only once in the analysis, length measurements were restricted to sharks displaying their right side scar patterns, that is sharks moving from left to right, inbound from deep water (a more frequently observed pattern than right to left, outbound movements). All sharks that were completely visible from both cameras, and could be individually identified, were measured. There was no body size bias in the ability to identify individuals. This was primarily dependent on the ambient light level, which was generally low within the two hours following sunrise or preceding sunset, and varied substantially in response to fluctuations in the density of particulate matter in the upper water layers.

Results

A total of 50 length measurements of 35 individual sharks were obtained from recordings made between 10 August and 15 September 2001 and between 10 July and 21 July 2002. The total of 50 includes one or two repeat measurements of 13 individuals that were filmed on multiple occasions. The average difference for these repeat measurements ((largest-smallest)/smallest) ×100) was 1.9% (maximum difference 4.7%). The body length-frequency distribution is roughly bell shaped with 80% of measurements falling between 180 cm and 300 cm (Figure 1). Mean, minimum and maximum lengths of the 35 sharks were 240 cm, 135 cm, and 353 cm, respectively. In most cases it was not possible to determine a shark's sex; however, all individuals greater than 280 cm were observed at close range under good illumination and could be sexed based on pelvic fin morphology. All sharks over 280 cm were females (n = 7).

The scars used to identify sharks varied from relatively small light patches to groups of long parallel lines running along the right lateral dorsal surface (Figure 2). The origin of these parallel scars is uncertain but they are consistent with injuries expected from hooking and subsequent entanglement with commercial fishing gear (dogfish longlines or bait lines attached to commercial prawn traps). Scars of this type were seen in 13 of the 35 sharks, a number that probably underestimates injury frequency because observations were confined to the right hand dorsal side; the left side and the jaw region, where divers frequently observe hooking injuries, were not visible in any of the measured sharks.

Figure 1

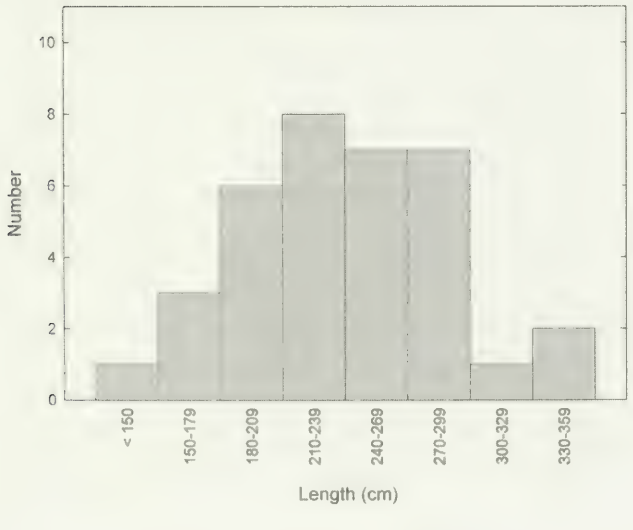

FIGURE 1. Body length-frequency relationship for 35 Bluntnose Sixgill Sharks observed at the Flora Islets reef.

Discussion

Newborn Bluntnose Sixgill Sharks are approximately 70 cm in length; minimum length at maturity is greater than 400 cm for females and greater than 314 cm for males (Ebert 1989). The size range at Flora Islets was 135 cm to 353 cm and all sharks over 280 cm were females, indicating that at Flora Islets all Bluntnose Sixgill Sharks are large juveniles and subadults. Smaller juveniles (75 cm) occur in deeper adjacent waters (Miller and Greenfield 1965) and there is a single record of a pregnant female (>400 cm) from the same area (S. McFarlane, Canada Fisheries and Oceans, Nanaimo, British Columbia, personal communication) The absence of adults and the smallest juveniles from Flora Islets reef is in agreement with data from Barkley Sound on the west coast of Vancouver Island. Here, visual length estimates of 55 *H. griseus* observed in shallow water by divers, ranged from 100 cm to a maximum of 300 cm for males and 360 cm for females (N. McDaniel, Subsea Enterprises, Vancouver, British Columbia, personal communication), whereas 43 immature sharks captured in the same area on deepwater longlines during a 1994 tagging study, varied in length from 86 cm to 400 cm (Canada Fisheries and Oceans, Nanaimo, British Columbia, unpublished report). These data indicate that in Barkley Sound the smallest juveniles probably stay in deep water, and that sexually mature fish are rare.

The apparent absence of the smallest juveniles from shallow water in Barkley Sound and at Flora Islets could result from their use of habitats or foraging behaviors different from those of larger conspecifics, possibly to enhance growth or deter cannibalism (Ebert 1989). The virtual lack of sexually mature adults in deep or shallow water at either site is problematic but could be connected to age-dependent movements whereby birth and juvenile development take place in productive inshore waters but mating occurs elsewhere, probably offshore. Geographic separation of adult and juvenile *H. griseus* has been reported previously (Ebert 1989; Castro et al. 1999) and is common in other shark species (Hoenig and Gruber 1990; Compagno 2001).

Approximately one third of the Bluntnose Sixgill Sharks observed at Flora Islets bore scars consistent with commercial gear entanglement; however, no in-

juries of this type were observed in the seven sharks greater than 280 cm or in the three smallest sharks (<180 cm). Although the sample size is small, this suggests that the largest sharks may be able to break off hooks or leaders without entanglement, whereas sharks below 280 cm may escape after a period of struggle, but with a probability that decreases as body size decreases. Unfortunately, there are no bycatch data available for *H. griseus* to test this hypothesis.

Body size-frequency distributions can provide information on a range of population-level processes in fishes including growth and mortality rates and size or age-based differences in habitat use (Moyle and Cech 1996). Length-frequency data for commercial species are readily available from catch statistics, and for non-commercial species are generally obtained from targeted collecting. However for large, deep water species, such as *H. griseus*, the collection of length-frequency data can be difficult or unacceptably destructive and the size structure of most large deep water fishes is poorly known (Casey and Taniuchi 1990). Here we have demonstrated that meaningful population data for such species can be obtained using non-invasive remote imaging techniques applied at strategically placed observing stations. Although extension of this technique to other species would require the identification of similar seasonal population aggregations, such seasonal movements are common in fishes. For example, we have recently used remote video imaging to quantify seasonal activity patterns in another little known deep water cartilaginous fish, the chimaerid *Hydrolagus colliei* (unpublished).

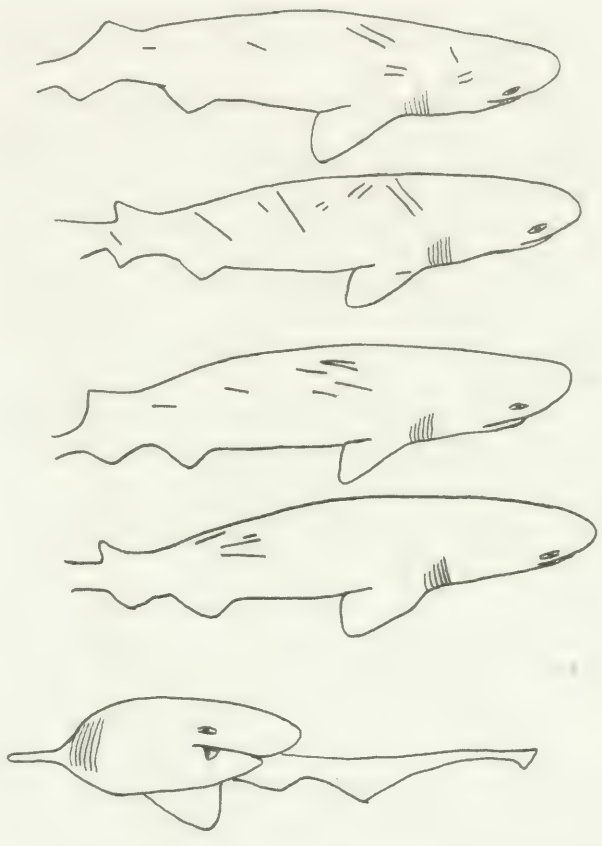

FIGURE 2. *Hexanchus griseus* outlines traced from single video frames. Injury markings are indicated by dark lines (injuries actually appear as lighter markings against a uniformly dark dorsal surface.) The top four sharks were viewed from their right side and show injuries along their lateral dorsal surface. The bottom shark (not measured) has a large indentation in its lower jaw caused by a hook.

Acknowledgments

A. Heath, L. Giguere, N. McDaniel, B. Parsons, and RD's family members provided valuable assistance at different points in this study. Two anonymous reviewers made helpful comments on an earlier draft of the manuscript. This work was carried out with the cooperation of the Province of British Columbia Parks Branch, and was supported by Memorial University of Newfoundland and NSERC Canada grants to R. Dunbrack and M. Ramsay.

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Received 2 November 2004
Accepted 7 October 2005

Use of Radio-Telemetry to Test for Investigator Effects on Nesting Mallards, *Anas platyrhynchos*

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Thorn, Terri D., Robert B. Emery, David W. Howerter, James H. Devries, and Brian L. Joynt. 2005. Use of radio-telemetry to test for investigator effects on nesting Mallards, *Anas platyrhynchos*. Canadian Field-Naturalist 119(4): 541-545.

We examined the effects of investigator activity on hatching rates of radio-marked wild female Mallards (*Anas platyrhynchos*), and evaluated the efficacy of radio-telemetry to minimize nest disturbance, characterize vegetation at nest sites, and mark nests for later relocation. Differences in hatching rates between birds that were flushed once (experimental) and those never flushed (control) approached significance ($P = 0.086$). However, hatching rates did not differ ($P = 0.588$) between the two groups when nests where investigator activity caused abandonment (30% of experimental nests) were removed from analysis. If the nest remained active, flushing the bird and visiting the nest once did not appear to increase the likelihood of the nest being depredated. We were able to locate 92% of radio-telemetry marked nests (control) after the female was no longer tending the nest. Radio-telemetry provides a technique to collect relatively unbiased nesting data for Mallards without disturbing the female.

Key Words: Mallard, *Anas platyrhynchos*, nests, hatching-rates, investigator effects, abandonment, radio-telemetry.

Investigating reproductive performance of waterfowl often requires physically locating nests followed by repeat visits until the nest's fate is determined. However, locating and revisiting nesting birds may influence reproductive performance by causing nest abandonment and by subsequently affecting renesting. Also, investigator visits to the nest may aid predators in locating and destroying nests and thus result in biased estimates of nest survival. Alternatively, predators may avoid human scent, leading to increased nest survival.

Potential negative influences of investigator activity on estimates of reproductive success have been recognized for decades in waterfowl research (Bennett 1938; Low 1940; Hammond and Forward 1956). Unfortunately, results of studies of investigator impact on waterfowl hatching rates have been equivocal. Earl (1950) and Hammond and Forward (1956), suggested that investigator presence lowered nesting success, whereas Gotmark and Ahlund (1984), Livezey (1980), and Sedinger (1990) did not find this to be true. In contrast, observer activity may increase nest abandonment (Balat 1969; Reed 1975; Livezey 1980).

Various methods (see Gotmark 1992 for review) have been used to test for investigator influences on reproductive parameters. However, locating and monitoring same-aged, undisturbed, natural duck nests (control) has been difficult. This can be crucial when trying to estimate accurately investigator-caused influences on hatching rates. Artificial nests have been used to facilitate such comparisons (e.g., Gottfried and Thompson 1978; Vacca and Handel 1988; Sullivan and Dinsmore 1990). Extrapolating estimates from artificial nests to natural nests might not be entirely valid, because artificial nests are "visited" when deployed (Gotmark et al. 1990; MacIvor et al. 1990; Hendricks and Reinking 1994; but see Olson and Rohwer 1998), and artificial nests may be poor substitutes for estimating hatching rates of natural nests (see Butler and Rotella 1998). Radio-telemetry offers a partial alternative by allowing remote monitoring of nesting waterfowl.

We used radio-telemetry to monitor duck reproductive performance in response to upland habitat manipulation during the Prairie Habitat Joint Venture (PHJV) assessment program of the North American Waterfowl Management Plan. Original PHJV assessment program protocols stated that if a female was suspected of having a nest, she was flushed to determine nest site location. We designed a study to determine whether flushing females and visiting a nest once reduced hatching rates. Specifically, our objectives were to: (1) determine the impact on hatching rates of flushing a female Mallard (*Anas platyrhynchos*) and visiting her nest early in the nesting cycle, (2) if there was an impact, determine its cause, and (3) evaluate the efficacy of our radio-telemetry nest-marking protocols.

Study Areas and Methods

Data were collected from three 64.75-km^2 areas in the prairie pothole region of Canada (Bellrose 1980; Poston et al. 1990). Study areas were centred approximately 1 km west of Belmont, Manitoba (49°25'N, 99°29'W), 5 km northeast of Davis, Saskatchewan (53°9'N, 105°37'W), and approximately 3 km west of Erskine, Alberta (52°19'N, 112°55'W). These landscapes,

characterized by flat to rolling topography, have been altered by cultivation for cereal and oil-seed crops, forage production, and livestock grazing.

We decoy-trapped (Sharp and Lokemoen 1987; Ringelman 1990) 135, 136 and 135 pre-laying female Mallards at Belmont, Davis and Erskine, respectively, during 6 – 28 April 1994. Females either were implanted with a radio transmitter (Olsen et al. 1992; all females at Belmont and Davis and 67 females at Erskine) or transmitters were anchor/sutured to their backs (Mauser and Jarvis 1991; Pietz et al. 1995; 68 females at Erskine). After marking, we located birds twice daily between 06:00 and 13:00 (Gloutney et al. 1993) using vehicle-mounted, null-array antenna systems and triangulation. Nesting attempts were suspected when triangulation placed a female in the same location for 5 consecutive mornings. We randomly allocated a subsample of all nesting attempts we encountered between 6 May and 19 June to either a control or an experimental group.

In the control group, nests were located and monitored only via telemetry; females were not flushed and nests were not visited while active. To estimate the location of control group nests we used hand-held antennas to take multiple bearings (≤ 5) around the probable nest site. The number of bearings and the distance away from the nest from which these bearings were taken varied with the complexity of the habitat type. For example, in very simple habitat configurations such as a small, isolated patch of nesting cover surrounded by sparse vegetation not suitable for nesting, we remained quite far (e.g. 100 – 150 m) from the nest and took only a few bearings. We aligned bearings with natural land features and/or small pieces of vinyl flagging and drew a detailed map of the estimated nest location to assist in relocating the nest when it was no longer active. Nesting site characteristics (habitat and vegetation type) were assigned to each nest from a distance. After a female Mallard was believed to be nesting, she was located via telemetry at least once each morning to monitor the status of the nest. If she was absent from the nest, a second location was obtained later the same day. If two consecutive telemetry readings indicated that the female was not in the area of the nest, we immediately searched for the nest, recorded nest-site vegetation characteristics, and determined the nest's fate (Klett et al. 1986).

In the experimental group, we visited the suspected nest site location and flushed the bird after triangulation placed her in the same location for five consecutive days. For each nest, we recorded vegetation characteristics around the nest site, number of eggs, and incubation stage (Weller 1956). We assumed a laying interval of one egg per day. Nest status was then monitored remotely using telemetry, and only when the female was absent for two consecutive telemetry locations was the nest visited again to determine its fate. Nest fate was considered abandoned due to investigator activity when the stage of nesting (number of eggs or stage of incubation) did not change between nest visits (Klett et al. 1986) and subsequent telemetry locations indicated that the female was still alive but had failed to return to the nest after we had flushed her.

Because the study was a part of the PHJV assessment program, where one of the main objectives was to determine waterfowl nesting habitat preferences, we risked misclassifying control-group females as nesting when they were not. To minimize this risk to our overall study objectives, we excluded from both groups those nesting attempts where nests were located < 30 m from wetlands with standing water.

Vegetation characteristics around the nest site were recorded at two different scales. The habitat within a 2-m radius around the nest was recorded as: (1) grassland, (2) hayland, (3) planted cover, (4) cropland, (5) woodland, (6) shrubland, or (7) wetland (Emery et al. 2005). These classifications were applied to any patch of habitat ≥10 m across in its narrowest dimension. Nest site vegetation within a 0.5-m radius of the nest bowl was characterized as one or more of the following types: (0) unvegetated, (1) annual crop, (2) upland graminoids-native, (3) upland graminoids-introduced, (4) upland forbs, (5) low shrubs (<1 m), (6) tall shrubs (1 – 6 m), (7) trees, (8) short emergent hydrophytes (< 0.5 m), and (9) medium/tall hydrophytes (> 0.5 m).

Data Analysis

To provide adequate sample sizes for analyses, data were pooled across habitats, study areas, and transmitter types. A chi-square test (PROC FREQ; SAS Institute 1997) was used to determine if there was a difference in the probability of hatching at least one egg (successful nest) between females that were flushed and those that were not. To test for investigator effects other than nest abandonment (i.e., predation), we removed those nests in the experimental group where investigators caused abandonment (Klett et al. 1986) and used Johnson's (1979) modification to the Mayfield method (Mayfield 1961, 1975) to estimate daily survival rates and hatching rates for the two groups. To detect differences in hatching rates, daily survival rates, weighted by exposure days, were used in a least-squares linear model (PROC GLM; SAS Institute 1997; Greenwood et al. 1995). To test for potential negative effects of radio-transmitters we compared clutch size and weighted daily survival rates between experimental nests and nests of non-radioed females found by systematic nest searches (Klett et al. 1986). We set decision levels at $\alpha = 0.05$. Our research was reviewed and approved (protocol 19920007) by the University of Saskatchewan Committee on Animal Care and Supply.

Results

We located 137 nests (64 control; 73 experimental). Experimental nests had a mean age when found of 5.8 days (SD = 3.0). Fifty-nine of the 64 (92%) con-

trol nests were physically located after they were no longer active. Because their success or failure could not be determined and habitat class and vegetation type could not be verified, the five control nests not located were excluded from further analyses. Differences in hatching rates between nests where the female was flushed (19.2%; experimental) and those where she was not flushed (27.5%; control) approached significance ($\chi^2 = 2.952$, 1 df, $P = 0.086$). When 22 nests (30.1% of experimental nests) that were abandoned due to investigator activity were removed, hatching rates did not differ between the two groups ($\chi^2 = 0.294$, 1 df, $P = 0.588$). Mayfield estimates (Klett et al. 1986) of hatching rates for experimental and control groups were 19.9% (95% CI = 11.8 – 33.4%) and 20.8% (95% CI = 12.8 – 33.8%), respectively. Weighted daily survival rates of experimental (0.9537) and control nests (0.9549) did not differ ($F = 0.001$, 1,5 df, $P = 0.977$). Nest loss due to predation occurred on average 10.1 days (SD = 7.8, n = 34) and 9.1 days (SD = 6.7, n = 35) following the date the nest was found or marked for experimental and control nests, respectively, and did not differ (t-test, $t = 0.57$, df = 67, $P = 0.568$). Weighted daily survival rates between experimental nests and nests of non-radioed females (0.9536, n = 44 nests) did not differ ($F = 0.0002$, 1,5 df, $P = 0.990$). Mean clutch size between the two groups (8.8 eggs, SD = 1.5, n = 32 for experimental nests; 9.3 eggs, SD = 1.1, n = 34 for nests of non-radioed females) approached significance (t-test, $t = 1.71$, df = 64, p = 0.093). Using radio-telemetry alone, we correctly estimated the habitat class for 55 of 59 (93%) control nests. Nest site vegetation was correctly estimated for 33 of 59 (56%) control nests.

Discussion

Low nesting success among prairie waterfowl (see Beauchamp et al. 1996), and particularly low nesting success among laying-stage nests (Miller and Johnson 1978), often necessitate locating nests early in laying if certain reproductive data are to be collected. But protocols requiring female Mallards to be flushed from their nests early in laying increase the likelihood of nest abandonment. Our investigator-caused abandonment rate of 30.1% was high and similar to the 24.3% investigator-caused abandonment rate for radio-marked Mallards encountered during the first year (1993) of our study. Livezey (1980) reported an investigator-caused abandonment rate of 6% with most abandonment occurring among nests found prior to the fourth day of laying. All investigator-caused nest abandonment ($n = 22$) in our study occurred the day the nest was first visited. Nests had a mean age at abandonment of 4.2 days (SD =1.8). While younger-age nests are more prone to abandonment (Ducks Unlimited Canada, Institute for Wetland and Waterfowl Research, unpublished data), other, unknown factors also probably influence abandonment, such as an individual female's tolerance to disturbance. We suspect radio-transmitters had minimal impact on the likelihood that females would abandon their nests following disturbance, but cannot verify this. Weighted daily survival rates did not differ between experimental nests and nests of non-radioed females ($P = 0.990$). However, differences in mean clutch size approached significance ($P = 0.093$). We were unable to compare investigator-induced abandonment rates between experimental nests and nests of non-radioed females because in a traditional rotational nest-searching scheme (see Klett et al. 1986), where nests are monitored at intervals of 7-10 days, the number of nests that are abandoned (either due to investigator disturbance or other factors) may be under-estimated because predators may destroy the nest before the next visit.

In contrast to the high investigator-related abandonment rates that we observed, only 6 (3 experimental, 3 control; 5.5%) nests were abandoned for reasons other than investigator disturbance. The mean age of abandonment for these nests was 12.5 days (SD = 6.2). Some of the highest reported incidences of natural abandonment were recorded by Duebbert et al. (1983) who found that Mallards nesting at high densities on an island abandoned 19%, 16% and 8% of their nests during the three years of their study. Because they did not visit the island during the nesting season, they concluded that inter- and intra-specific interactions, not investigator activity, were the major causes of abandonment (Duebbert et al. 1983).

When nests where investigator disturbance caused abandonment were removed from analysis, there was no difference in hatching rates or weighted daily survival rates between experimental and control nests. The temporal pattern of nest loss also did not differ among groups. It would appear then, that flushing a female Mallard and visiting the nest once did not increase the likelihood of predation. Thirty-four of 51 (66.7%) experimental nests and 37 of 59 (62.7%) control nests were destroyed by predators. Gotmark (1992) found a decrease in hatching rates attributable to investigator activity in 18% of published accounts where mammals were the dominant predators. In contrast, when avian predators dominated the egg-eating predator community, investigator disturbance led to increased predation of eggs (Gotmark 1992). Both avian and mammalian predators were common on our study sites (Ducks Unlimited Canada, Institute for Wetland and Waterfowl Research, unpublished data), yet we did not see increased predation resulting from investigators visiting nests once.

Investigator activity during early egg-laying appears to impact Mallard hatching rates through a high rate of nest abandonment. Although most modern waterfowl studies account for nests for which the investigator caused abandonment when estimating hatching rates (Klett et al. 1986), investigator-caused abandonment may lead to increased renesting and, subsequently, biased estimates of other reproductive parameters.

For example, re-nesting birds usually produce smaller clutches (Rohwer 1992). Also, late-hatched ducklings may have lower survival and recruitment rates (Dzus and Clark 1998; Dawson and Clark 2000; Anderson et al. 2001; Blums et al. 2002; and see Rohwer 1992 for review of reproductive patterns). Causing birds to abandon their nests and, when re-nesting, select a new nest site also may bias estimates of habitat use and, if the new nest site has a different vulnerability to predation than the original nest, hatching rates. Although investigator-induced abandonment rates in a traditional rotational nest-searching scheme (Klett et al. 1986) typically would not approach the rates found in this study because most of our nests were found early in laying, the extent to which traditional nest search studies under-estimate abandonment rates should be investigated further. Radio-telemetry should provide a useful tool for that investigation.

Using radio-telemetry, we were able to collect accurate nesting information without disturbing the birds or visiting the nests until after the nests were no longer active. We were able to locate over 90% of the nests after they had hatched, were destroyed, or were abandoned by the female. Even if it had not been possible to locate such a high percentage of nests, we have demonstrated that it is possible to classify habitats with a high degree of accuracy using just telemetry. Not surprisingly, however, as the resolution of the habitat information became finer (i.e., nest site vegetation) our success rate declined. Nevertheless, radio-telemetry appears to provide a way to collect nesting data for waterfowl during the early egg-laying stage while avoiding the possibility of biasing data through increased abandonment rates.

Study results led to protocol change for the remaining years (1995 – 2000) of the PHJV assessment program. We estimated nest locations via triangulation and physically located nests later when females were absent from the nest areas. Investigator-induced abandonment due to accidental flushes during nest-marking averaged only 3.9% for the 22 study areas investigated during this period.

Acknowledgments

We gratefully acknowledge the cooperation of the Belmont, Davis and Erskine landowners for granting us access to their land. C. Archambault, B. Boldaun, D. Brooker, S. Cronin, F. DeZeeuw, V. Fairman, M. Francis, K. Hento, N. Herbert, P. Johnston, T. Krolikowski, D. Kuhn, G. Lacroix, C. Lamey, S. Leach, D. Marsh, K. Mott, A. Mullie, B. Parkin, K. Pilgrim, M. Post, K. Rattray, F. Rice, T. Sallows, D. Shaw, R. Terwilliger, P. Thorpe, J. Trevor, P. Varney, A. Viveiros, J. Walker and C. Wilke helped greatly with data collection. M. Barr, B. Calverley, K. Eskowich, A. Hak, M. Kornder, I. McFarlane, K. Remple, A. Richard, K. Schmitt and B. Thompson provided additional help during decoy trapping and we express our thanks. Ducks Unlimited staff from Manitoba, Saskatchewan, and Alberta provided invaluable support during site selection and landowner contacts. We thank R. R. Cox, A. J. Erskine, and three anonymous reviewers for providing helpful comments on earlier drafts of this manuscript. Financial support for this study was provided by Ducks Unlimited Canada, Ducks Unlimited Inc., the Canadian Wildlife Service, the National Fish and Wildlife Foundation, and the North American Wetlands Conservation Council through the Institute for Wetland and Waterfowl Research.

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Received 3 August 2004
Accepted 4 November 2005

Food Habits of Dabbling Ducks During Fall Migration in a Prairie Pothole System, Heron Lake, Minnesota

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Wersal, Ryan M., Brock R. McMillan, and John D. Madsen. 2005. Food habits of dabbling ducks during fall migration in a prairie pothole system, Heron Lake, Minnesota. Canadian Field-Naturalist 119(4): 546-550.

We conducted an analysis of dabbling duck food habits in the fall of 2002 and 2003 in the Heron Lake system. Gizzard contents of hunter-harvested birds were analyzed using the percent aggregate volume method to determine what food items were consumed and in what quantity. Curltop Ladysthumb (*Polygonum lapathifolium*) was the food item consumed most often (82.2%) and in the greatest volume (34.2 ml). Sago Pondweed (*Stuckenia pectinata*) was the only food item of which multiple plant parts were consumed. However, the seeds and tubers only comprised 1.27 and 0.07 of the total aggregate percent.

Key Words: Food habits, waterfowl, gizzard contents, aggregate volume, submersed macrophytes, Curltop Ladysthumb, *Polygonum lapathifolium,* Sago Pondweed, *Stuckenia pectinata.*

The food habits of waterfowl are often diverse and vary throughout a state and flyway (Havera 1999). It is necessary to have a firm understanding of food use of waterfowl for effective management and to provide a diversity of high quality wetland habitat (Havera 1999). Quality habitat (abundant and available) is the most important ecological component affecting waterfowl populations which includes the essential elements of food, cover, and water (Baldassarre and Bolen 1994). Wetland habitats are crucial in providing food that waterfowl prefer instead of areas where they have to feed on only what is available (Havera 1999). Waterfowl consume a wide variety of vegetation of which submersed macrophytes constitute a large fraction of the total food items consumed (Martin and Uhler 1939; Havera 1999).

Submergent macrophyte communities are a direct source of waterfowl food and indirectly serve as an environment for aquatic macroinvertebrates (Baldassarre and Bolen 1994). Submersed macrophytes can comprise the bulk of food items consumed by migrating waterfowl (Martin and Uhler 1939). For example, Curlyleaf Pondweed (*Potamogeton crispus*) on average yields 140 kg/ha of seed per season, or enough to sustain 2470 Mallards (*Anas platyrhynchos*) per hectare per day (Hunt and Lutz 1959). The pondweeds (*Potamogeton* and *Stuckenia* spp.) ranked first, by volume, as food consumed by 18 species of waterfowl (Martin and Uhler 1939).

Of the pondweeds, *S. pectinata* is said to be one of the most sought after food plants by waterfowl (Kantrud 1990). *Stuckenia pectinata* is probably the most important single waterfowl food plant on the continent and is responsible for about half, or more, of the total food percentage credited to the genus *Potamogeton* [*Stuckenia*] (Martin and Uhler 1939). As a food item, *S. pectinata* can form a significant portion of foods found in gizzards of fall staging populations, pre-molting birds, flightless molting ducks, and ducklings (Chura 1961; Hay 1974; Keith and Stanislawski 1960).

Historically, the Heron Lake system has been an important staging area for fall migrating waterfowl due to its extensive beds of aquatic macrophytes. An account from 1906 reported over 700 000 Canvasbacks (*Aythya valisineria*) on North Heron Lake feeding on mats of Wild Celery (*Vallisneria americana*) (Berry and German 1999). The Wild Celery disappeared in 1922 as a result of the Common Carp (*Cyprinus carpio*) (Berry and German 1999) and today sago pondweed is the only submersed macrophyte found in the Heron Lake system (Case 2003; Case and Madsen 2004). Poor water quality is attributed to the lack of macrophyte growth, a likely result of runoff from the high percentage of agricultural land surrounding the lakes and point source pollution including sewage and industrial effluent from nearby cities (Case 2003; Case and Madsen 2004). The Heron Lake system also has high sediment resuspension and increased turbidity due to shallow water and a large fetch (Case 2003; Case and Madsen 2004).

Although the Heron Lake system is in a degraded state, it is still used by migrating waterfowl as it is one of the largest shallow lake systems in the region. Due to its continued importance to waterfowl we conducted a preliminary investigation of the food habits of fall migrating dabbling ducks staging in the Heron Lake system in October of 2002 and 2003. The primary objective was to determine the principal foods utilized by fall migrating dabbling ducks, with particular interest to aquatic macrophytes, especially sago pondweed.

Methods

Site Description

The Heron Lake system is located in Jackson County, Minnesota (43.72333°N 95.2325°W) and comprises four lakes; of which South Heron and North Heron Lakes were used in this study. The four lakes have a mean depth of less than 1.5 m and a combined surface area of approximately 3200 hectares. South Heron Lake (1220 ha) can be divided into a north bay and a south bay by differing sediment characteristics (Case and Madsen 2004). South Heron Lake is connected to North Heron Lake via Division Creek located in the northern most part of the lake. North Heron Lake (1350 ha) is a flat, shallow lake with little change in depth from one end to the other. North Marsh (430 ha) is a small shallow water body located at the northern edge of North Heron Lake. Birds harvested on North Marsh were included in North Heron Lake due the close proximity of the lakes. Duck Lake (190 ha) was not included in this study due to the lack of public access for hunters.

Food Habit Collection

Hunters from South Heron and North Heron Lakes (including North Marsh) were asked to collect the gizzards from their harvested birds during each hunting day in 2002 and 2003. The harvested samples were placed in 1.06-l Whirl-pak bags filled with a 75% ethyl alcohol solution. A waterproof label was affixed to each bag to record the lake, the species and sex of the bird, and the date of harvest. The collected samples were stored in a refrigerator at approximately 4°C until processing.

In the lab, each gizzard was opened and its contents washed through a series of standard testing sieves. Number 20 (850 micrometer), number 35 (500 micrometer), and number 140 (106 micrometer) sieves were used to separate food items by size. Samples were processed using the dry volumetric method (Rogers and Korschgen 1966). Each food item was placed in plastic measuring dishes and dried at 55°C for 48 hours in a constant temperature oven. We summarized food items by species of waterfowl. Organic and inorganic materials were separated using a dissecting microscope. Items within a sample were separated according to species of plant or animal.

Volumetric measurements were made using a micro-syringe (used for small food items and items found in small quantities), 10 ml, or 25 ml graduated cylinders (Rogers and Korschgen 1966). We placed food items into the micro-syringe or graduated cylinder and compressed slightly with a small dowel to remove any air pockets. Once the air had been removed we recorded the volume of that food. We identified plant items to genus level (if postmortem digestion had not rendered the item unidentifiable) and macroinvertebrates were identified to family. The identification of seeds was made using descriptions and diagrams by Martin (1951, 1954) (for *Polygonum* and *Potamogeton* spp.), the text by Martin and Barkley (1961), and the taxonomic key by Crow and Hellquist (2000). Seed identifications were verified by a taxonomic expert at Mississippi State University. Scientific and common names for plant species followed the Checklist of North American Plants for Wildlife Biologists by Scott and Wasser (1980). We identified invertebrates using the taxonomic key by Pennak (1978).

Data Analysis

We used percent occurrence to describe the frequency of a food item in the samples and to assess the relative use of a food item by waterfowl. We expressed volumes of food items as the percent of aggregate volume (Martin et al. 1946). Aggregate volume quantifies the relative importance of food types as it addresses the amount of a food item consumed by waterfowl. Individuals from the same species were aggregated per food item and the sum of each food item was then divided by the total volume of food consumed by all individuals.

Percent Aggregate Volume was calculated as (1):

$$\frac{\sum (\text{volume of food item}_i \text{ across all animals in the sample}) \times 100}{\text{Total volume of all foods consumed in the sample}}$$

Results

Harvested Waterfowl

We collected 63 gizzards from fall migrating waterfowl, 46 gizzards in 2002 and 17 gizzards in 2003 (Table 1). Blue-winged Teal (See Table 1 for scientific names) comprised the majority of the samples taken, followed by Green-winged Teal, Mallards, and Wood Ducks. Other species represented included the Northern Shoveler and Northern Pintail.

Plant material comprised 99.4% of the total aggregate percent of food items collected (Table 2). *Polygonum lapathifolium* seeds made up the largest aggregate percent of food items collected from waterfowl in this wetland system. *Potamogeton pusillus* seeds ranked second in total aggregate percent followed by the seeds of Rice Cutgrass (*Leersia oryzoides*) and *P. dichotomiflorum*. Soybeans (*Glycine max*) appeared to rank higher in aggregate percent than *P. dichotomiflorum*; however, they were found in large amounts only in the few Wood Ducks harvested in this study. The fact that it was only found in a few individuals overestimated its volumetric importance.

Animal matter constituted only (0.5%) of the total aggregate percent (Table 2). Water boatmen (Corixidae) were consumed more frequently and in the greatest amount. Blue-winged Teal accounted for the majority of the midges (Chironomidae) consumed. Other dabbling ducks that consumed invertebrates include Green-winged Teal, Mallards, and Gadwall which consumed Planorbidae, Physidae, and Plecoptera invertebrates, respectively.

Discussion

Polygonum lapathifolium was the most important food consumed by dabbling ducks; it occurred in the

TABLE 1. Species list of dabbling ducks harvested in the Heron Lake system during the fall hunting seasons of 2002 and 2003.

Species	n	% of Sample	Female	Male	Unknown
Blue-winged Teal (*Anas discors*)	27	42.8	9	1	17
Green-winged Teal (*Anas crecca*)	14	22.2	7	4	3
Mallard (*Anas platyrhynchos*)	13	20.6	8	5	0
Wood Duck (*Aix sponsa*)	4	6.3	1	2	1
Northern Shoveler (*Anas clypeata*)	2	3.1	1	1	0
Gadwall (*Anas strepera*)	2	3.1	1	1	0
Northern Pintail (*Anas acuta*)	1	1.5	0	0	1
Total	**63**	**100.0**	**27**	**14**	**22**

TABLE 2. Gizzard contents (± 1 SE) of harvested dabbling ducks in the Heron Lake system during October of the 2002-2003 hunting seasons. Food items without a standard error had less than two birds containing that food item. All food items are seeds unless otherwise noted.

Food Item	**Frequency (%)**	**Volume (ml)**	**Aggregate (%)**
Amaranthus spp.	46.77	0.45 ± 0.15	0.73 ± 0.15
Bidens spp.	9.68	0.05 ± 0.02	0.08 ± 0.01
Carex spp.	40.32	0.24 ± 0.06	0.39 ± 0.06
Ceratophyllum demersum	37.10	0.67 ± 0.18	1.09 ± 0.18
Chenopodium spp.	3.23	0.05 ± 0.02	0.08 ± 0.01
Cyperus erythrorhizos	6.45	0.08 ± 0.02	0.13 ± 0.02
Cyperus odoratus	46.77	0.34 ± 0.03	0.55 ± 0.03
Echinochloa crusgalli	22.58	1.29 ± 0.38	2.10 ± 0.38
Eleocharis spp.	9.68	0.01 ± 0.00	0.02 ± 0.01
Glycine max	1.61	2.80	4.57
Leersia oryzoides	19.35	2.75 ± 0.57	4.49 ± 0.53
Lolium spp.	1.61	0.03	0.05
Panicum dichotomiflorum	41.94	2.24 ± 0.88	3.65 ± 0.88
Pinus spp.	1.61	0.06	0.10
Polygonum lapathifolium	82.26	21.01 ± 1.73	34.27 ± 1.73
Polygonum pennsylvanicum	14.52	0.15 ± 0.01	0.24 ± 0.01
Polygonum persicaria	8.06	0.02 ± 0.01	0.03 ± 0.01
Potamogeton natans	8.06	0.37 ± 0.09	0.60 ± 0.09
Potamogeton pusillus	58.06	5.37 ± 0.64	8.76 ± 0.64
Potamogeton (unidentified)	11.29	0.08 ± 0.01	0.13 ± 0.01
Sagittaria latifolia	6.45	0.80 ± 0.39	1.31 ± 0.39
Scirpus acutus	41.94	2.15 ± 0.08	3.51 ± 0.08
Scirpus fluviatilis	25.81	1.96 ± 0.30	3.20 ± 0.30
Scirpus validus	17.74	0.17 ± 0.01	0.28 ± 0.01
Stuckenia filiformis	4.84	0.42 ± 0.18	0.69 ± 0.18
Stuckenia pectinata	22.58	0.78 ± 0.08	1.27 ± 0.08
Stuckenia pectinata (tuber)	1.61	0.04	0.07
Zanichellia spp.	1.61	0.02	0.03
Zea mays	1.61	6.80	11.09
Setaria spp.	1.61	0.03	0.05
Macerated Items	32.26	9.75 ± 0.35	15.91 ± 0.35
Chironomidae	3.23	0.07 ± 0.01	0.11 ± 0.01
Corixidae	16.16	0.12 ± 0.02	0.20 ± 0.02
Physidae	1.61	0.07	0.11
Planorbidae	3.23	0.01 ± 0.00	0.02 ± 0.01
Plecoptera	1.61	0.02	0.03
Unidentified Invertebrate	3.23	0.03 ± 0.01	0.05 ± 0.01
Total Food		**61.30 ± 0.63**	**100.00 ± 1.04**
Total Plant		**60.98 ± 0.75**	**99.48 ± 1.22**
Total Animal		**0.32 ± 0.01**	**0.52 ± 0.02**

majority of species, and ranked highest in percent aggregate volume. These results concur with a similar study conducted in Illinois where *P. lapathifolium* occurred in 95% of all Blue-winged Teal gizzards sampled (Havera 1999). *Polygonum lapathifolium* is widely distributed in the Heron Lake system as noted by vegetation transects (Heron Lake Watershed District, unpublished data) making it readily available as a food source. *Stuckenia pectinata* was also readily available as a food source as it is the only submersed macrophyte found in the Heron Lake system (Case and Madsen 2004). It had a frequency of occurrence of 74.5% and 46.8% for North Heron and South Heron Lakes in 2001 (Case and Madsen 2004). Likewise, in a similar study *S. pectinata* had a frequency of occurrence of 77.6% and 52.8% for South Heron Lake in 2002 and 2003, respectively; as well as 26.5% in North Heron Lake during 2003 (Wersal 2004). *Stuckenia pectinata* was the only item that dabbling ducks consumed multiple parts of the plant. Seeds and tubers were found in gizzards analyzed in this study indicating that *S. pectinata* was utilized as a source of food for dabbling ducks. Kantrud (1986) estimated that a single *S. pectinata* dominated lake could support a large percentage of the continental migrating waterfowl population for a month during fall staging.

The reduced abundance of *S. pectinata* observed in the Heron Lake system in 2003 may have shifted feeding to other areas of the system where other food items were more abundant. "Superior availability after all is the guiding principle in the choice of foods by birds" (McAtee 1918). Most dabbling species are non-selective in their feeding habits and feed primarily on aquatic or moist soil vegetation that is abundant in a given location (Havera 1999). Mallards have not been found to be selective foragers, but consume what is abundant in the area (Nummi 1993). Blue-winged Teal change their diets in relation to varying wetland conditions to take advantage of abundant food resources (Thompson et al. 1992). Northern Pintails have been found to shift their food selection based on availability of food items in a given area (Euliss and Harris 1987).

Analyzing food habits in a given area using gizzards as opposed to esophagus samples may introduce a bias toward hard-bodied food items as a result of the differences in breakdown rates of hard versus soft-bodied items (Swanson and Bartonek 1970). However, Wright (1959) found that Mallards contained approximately the same food items in their gizzards as they did in their esophagus. Furthermore, the esophagus of hunter-killed waterfowl are most often empty or contain small amounts of food (Drake 1970; Perry and Uhler 1982) resulting in the reliance on gizzards to obtain sufficient sample numbers (Havera 1999). Also, the bias of hard-bodied items may not be as critical in food habit analyses conducted in the fall because animal matter is not as prevalent in the diets of most species of waterfowl, most notably dabbling ducks (Havera 1999).

The dabbling ducks harvested in the Heron Lake system consumed a variety of food items during fall migration. The most observed waterfowl species in the Heron Lake system were Mallards, Blue-winged Teal, Green-winged Teal, and Canada Geese, an observation supported by the gizzards collected in this study. Diving species still utilize the Heron Lake system; however, not to the extent of dabbling ducks. The decrease in use of the system by diving ducks can be attributed to the reductions in submersed macrophytes within the system.

The results of this study suggest that submersed macrophytes were not as important to dabbling ducks as moist soil vegetation. Dabbling ducks are finding food; however, management should focus on providing more food that ducks prefer such as moist soil vegetation instead of having ducks feed only on what is available. Likewise, improvements in water quality should facilitate increases in *S. pectinata* populations and the re-establishment of other aquatic macrophytes to provide a diversity of food items for diving species. Future studies in the system should focus attention towards collecting larger sample sizes; analyze changes in food availability based on management within the system; and analyzing esophagus samples to see if differences in food items exist from that of gizzards.

Acknowledgments

This project was funded by the U.S. Fish and Wildlife Service in cooperation with the Heron Lake Watershed District and the North Heron Lake Game Producers Association. A special thanks to Jason Neyens and Todd Boonstra for their diligent work in sorting through the gizzard samples. Victor Maddox provided verification of seed identifications. Earlier reviews of this manuscript were provided by Eric Dibble, Victor Maddox, and Randy Markl. We would also like to thank those hunters who took the time to collect samples used in this study. Publication number J-10652 of the Mississippi Agriculture and Forestry Experiment Station.

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Received 29 January 2005
Accepted 1 November 2005

Added in proof

Wersal, R. M., J. D. Madsen, B. R. McMillan, P. D. Gerard. 2006. Environmental factors affecting biomass and distribution of *Stuckenia pectinata* in Heron Lake System, Minnesota, USA. Wetlands 26: 313-321.

Body Weights of Adult and Juvenile Northern Pocket Gophers, *Thomomys talpoides*, in Central Alberta Alfalfa Fields

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Proulx, Gilbert. 2005. Body weights of adult and juvenile Northern Pocket Gophers, *Thomomys talpoides*, in central Alberta alfalfa fields. Canadian Field-Naturalist 119(4): 551-559.

In an effort to recognize adults from juveniles in late summer and early fall, carcasses of Northern Pocket Gophers (*Thomomys talpoides*) captured from April to October 1994 in a pure alfalfa (*Medicago* spp.) field in Camrose and a mixed alfalfa-orchard grass (*Dactylis glomerata*)-dandelion (*Taraxacum* spp.) field in Lacombe, in central Alberta were analyzed. Mean weights of adult males and females were significantly ($P < 0.05$) larger than those of juveniles with near-adult body sizes in late summer and early fall. On the basis of the limits of 95% confidence intervals for individual values in Camrose and Lacombe, live-captured males weighing < 130 g could be classified as juveniles; those that are > 180 g would be adults. Males weighing between 130 and 180 g could be either juveniles or adults. Live-captured females weighing < 110 g would likely be juveniles. With larger animals, the pubic symphysis should be used to distinguish young females from adults. Given the variability of body weight in Northern Pocket Gophers, it is suggested that criteria for aging based on weight be derived for local populations in specific habitat types. On average, Northern Pocket Gopher males and females from Camrose were significantly ($P < 0.05$) heavier than those of Lacombe. Animals from both fields were, on average, heavier than those previously studied in natural-vegetation communities. Differences in the food nutritional quality may explain the observed variation in body weights among populations.

Key Words: Northern Pocket Gopher, *Thomomys talpoides,* Alfalfa, *Medicago* sp., body weight, Alberta.

In ecological studies, being able to recognize adults from juveniles in late summer and early fall without killing animals is useful to estimate summer mortality rates and population changes in response to environmental fluctuations (Caughley 1977), and conduct behavioral and physiological investigations (Miller 1952). Northern Pocket Gopher (*Thomomys talpoides*) adults and juveniles are difficult to tell apart in late summer and early fall on the basis of weight. In British Columbia orchard-old field habitats, from July to September, Sullivan et al. (2001) used three age classes of Northern Pocket Gophers based on body weight: juveniles (young of the year, which do not breed until the next year) < 49 g; subadults (individuals of which 50% are mature in the upper weight class) 49-60 g; and adults (≥ 50% of individuals sexually mature in the lowest weight class) ≥ 61 g. However, previous studies on the body size of *Thomomys talpoides* (Smith 1940; Hansen 1960; Hansen and Bear 1964; Tryon and Cunningham 1968; Hansen and Reid 1973) and *Thomomys bottae*, Valley Pocket Gopher, (Howard and Childs 1959; Daly and Patton 1986; Patton and Brylski 1987) showed that animal weights varied among pocket gopher populations due to habitat types, altitude, latitude, and seasons (Hansen and Reid 1973). Patton and Brylski (1987) found that growth rates and body sizes of pocket gophers inhabiting alfalfa monocultures were greater than those of pocket gophers inhabiting natural-vegetation communities. Then, one may wonder about the usefulness of aging criteria based on weight developed in different regions and habitats to study Northern Pocket Gopher populations in alfalfa (*Medicago* spp.) fields of central Alberta.

According to Reid (1973), young-of-the-year Northern Pocket Gophers would attain near-adult body weight approximately 180 days after birth. That is to say that, in Alberta alfalfa fields where young are born in April-May (Proulx 2002), they would be similar in body size to adults during August-October. However, the growth rate of juvenile pocket gophers may be highly variable from one population to another (Daly and Patton 1986), and Reid's (1973) estimate may not be applicable to central Alberta populations.

Few complete data have been published on body weights of Northern Pocket Gopher populations. Although the Northern Pocket Gopher is common in western Canada (Proulx 2004), little is known about body weights of age and sex classes from different habitats. Within the context of a multi-year ecological study of Northern Pocket Gophers in Alberta alfalfa fields, I collected carcasses to compare body weights of adults and juveniles during summer and early fall in order to determine weight classes that could be used to age animals in live-capture programs. I also wanted to compare the mean weights of adults from central Alberta alfalfa fields to those reported in the scientific literature for other regions and habitat types. I hypothesized that in late summer-early fall: (1) on average, adults would be heavier than juveniles; (2) individual body weights of adults and juveniles would overlap; (3) body weight categories may be established to differentiate some juveniles from adults; and (4) mean body weights of adults inhabiting alfalfa fields would be larger than those of adults from natural-vegetation communities.

Methods

The study was carried out in two alfalfa fields of central Alberta, in the communities of Camrose and Lacombe. The Camrose field was a 3-year-old pure alfalfa stand with a high forage yield and excellent second cutting (Alberta Agriculture 1992*). The Lacombe field was approximately 5 years old, and corresponded to a mixture of alfalfa with orchard grass (*Dactylis glomerata*) and abundant dandelion (*Taraxacum* spp.). Alfalfa was cut once and thereafter the field was used as pasture. Spring adult populations were estimated at 22.4 animals/ha in Camrose (Proulx 1997), and 23.5/ha in Lacombe (Proulx 1995*). The ratio male:female was 0.7:1 in Camrose, and 0.75:1 in Lacombe. Mean litter size was significantly larger in Camrose ($\bar{x}$ = 6.4; standard deviation = 1.4) than in Lacombe (5.1 ± 1.1) (Proulx 2002)

In 1994, kill-trapping was conducted from 18 April to 27 October. Trapping methodology was described by Proulx (1997). Animals were individually marked in the field, and frozen. The weight, sex and age were determined in the laboratory. In central Alberta, females produce only one litter (Proulx 2002). The size of the reproductive organs was used to distinguish young-of-the-year from adults. Young males have smaller testes, and young females have smaller ovaries and narrower uterine horns than adults (Hansen 1960; Hansen and Reid 1973). As precocial breeding is not known to occur in Alberta populations (Proulx 2002; Proulx and Cole 2002), the pubic symphysis was also used to distinguish young females from adults; in adult females the bones are resorbed, leaving a pubic gap (Hisaw 1924; Hansen 1960).

An analysis of variance followed by the Tukey test was used to compare mean weights between Camrose and Lacombe population samples (Zar 1999). Student t-tests were used to compare mean body weights of Northern Pocket Gophers of Camrose and Lacombe populations to those of populations reported in the scientific literature. Probability values $P \leq 0.05$ were considered statistically significant.

Results

Males

Mean weights of Camrose adult males differed significantly ($F_{2,63} = 5.9$, $P < 0.005$) among samples collected from 18 April to 31 May. Animals captured in late May were significantly ($P < 0.005$) lighter than those collected earlier in the year (Table 1). In Lacombe, mean weights of adult males were similar ($F_{3,86} = 1.7$, $P > 0.05$) among samples collected from 18 April to 31 May (Table 1).

Mean weights of juvenile males differed significantly among samples in Camrose ($F_{4,74} = 21.7$, $P < 0.005$) and Lacombe ($F_{4,67} = 11.3$, $P < 0.005$) (Table 1). Juveniles captured in September-October were the heaviest; they were similar in size ($P > 0.05$) to those captured in August-September (Table 1).

Mean weights of adults and juveniles differed significantly in Camrose ($F_{4,74} = 21.7$, $P < 0.005$) and Lacombe ($F_{5,156} = 80.2$, $P < 0.005$). In both study areas, the mean adult weight was larger ($P < 0.001$) than that of each juvenile sample collected from June to October (Table 1). In Camrose, the limits of 95% confidence intervals for individual values were 142-230 g for adults, and 108-172 g for September-October juveniles. In late summer-early fall, although males were, on average, heavier than juveniles, there was a marked overlap between age class weights. Then, on the basis of weight alone, live-captured animals weighing between 142 and 172 g could be classified as either adults or juveniles. Those weighing < 142 g could be juveniles while those > 172 g could be adults. In Lacombe, the limits of 95% confidence intervals for individual values were 136-213 g for adults, and 106-174 g for September-October juveniles. Live-captured animals weighing between 136 and 174 g could then be classified as either adults or juveniles. Those weighing < 136 g could be juveniles while those > 174 g could be adults.

Females

In Camrose, mean weights of adult females were similar ($F_{3,113} = 1.0$, $P > 0.05$) among samples collected from 18 April to 27 June (Table 1). In Lacombe, mean weights of adult females differed significantly ($F_{4,107} = 3.0$, $P < 0.05$) among samples collected from 18 April to 27 October. Animals captured in late May and in August-October were the only samples to differ significantly ($P < 0.005$) from each other (Table 1).

Mean weights of juvenile females differed significantly among samples in Camrose ($F_{2,38} = 20.3$, $P < 0.005$) and Lacombe ($F_{3,34} = 11.8$, $P < 0.005$) (Table 1). In Camrose, juveniles captured in August-September and in July were of similar ($P > 0.05$) size, but were larger ($P < 0.05$) than those of June (Table 1). In Lacombe, juveniles captured from August to October were of similar ($P > 0.05$) size, but were larger ($P < 0.05$) than those of July (Table 1).

Mean weights of adults and juveniles differed significantly in Camrose ($F_{3,154} = 120.5$, $P < 0.005$) and in Lacombe ($F_{4,145} = 27.5$, $P < 0.005$). In both study areas, the mean weight of adults was larger ($P < 0.001$) than that of each juvenile sample collected from June to September (Table 1). In Camrose, the limits of 95% confidence intervals for individual values were 126-195 g for adults, and 89-163 g for August-September juveniles. Although female adults were, on average, heavier than juveniles, there was a marked overlap between age class weights. Therefore, on the basis of weight alone, live-captured animals weighing between 126 and 163 g could be either adults or juveniles. Females weighing < 126 g could be juveniles while those > 163 g could be adults. In Lacombe, the limits of 95% confidence intervals for individual values were 113-175 g for adults and 101-180 g for September-

TABLE 1. Weights of adult and juvenile Northern Pocket Gophers in Camrose and Lacombe alfalfa fields, summer and fall 1994.

		Male weights (g)*									Female weights (g)*							
		Adult				Juvenile					Adult				Juvenile			
Population	Period	*n*	$\bar{x}$	SD	CI	*n*	$\bar{x}$	SD	CI	Period	*n*	$\bar{x}$	SD	CI	*n*	$\bar{x}$	SD	CI
Camrose	18–30 April	21	193[a]	16.4	–	–	–	–	–	18–30 April	31	159.8[a]	20.8	–	–	–	–	–
	1–14 May	25	191[a]	18.0	–	–	–	–	–	1–14 May	43	164.4[a]	14.7	–	–	–	–	–
	15–31 May	20	172.8	27.4	–	–	–	–	–	15–31 May	38	158.0[a]	17.1	–	–	–	–	–
	10–30 June	–	–	–	–	18	86.1	15.2	56–116	3–27 June	5	157.8[a]	23	–	–	–	–	–
	5–14 July	–	–	–	–	23	114.0[b]	14.8	85–143	14–27 June	–	–	–	–	12	86.6	14.0	87–114
	15–31 July	–	–	–	–	7	117.3[b]	17.4	83–151	1–22 July	–	–	–	–	21	108[a]	11.6	85–131
	1–31 August	–	–	–	–	16	124.6[a,b]	23.0	80–170	5 August–30 September	–	–	–	–	8	126.1[a]	18.7	89–163
	2 September–14 October	–	–	–	–	15	140.3[a]	16.4	108–172		–	–	–	–	–	–	–	–
	All	66	186.1	22.4	142–230	–	–	–	–	All	117	160.8	17.6	126–195	–	–	–	–
Lacombe	18–30 April	42	177.0[a]	17.8	–	–	–	–	–	18–30 April	25	144.4[a,b]	14.9	–	–	–	–	–
	1–14 May	24	169.5[a]	23.8	–	–	–	–	–	1–14 May	37	146.6[a,b]	14.7	–	–	–	–	–
	15–31 May	19	178.9[a]	15.8	–	–	–	–	–	15–31 May	36	138.4[a]	15.0	–	–	–	–	–
	10–30 June	–	–	–	–	12	91.5[a]	21.1	50–133	1 June – 31 July	7	143.7[a,b]	21.1	–	–	–	–	–
	17–31 July	–	–	–	–	19	107.1[a]	13.4	81–133	17–31 July	–	–	–	–	16	99.3	13.1	74–125
	1–15 August	–	–	–	–	22	125.0[b]	22.8	80–170	1–15 August	–	–	–	–	6	126.5[a]	23.0	81–172
	17 August–13 September	–	–	–	–	13	130.0[b]	17.9	95–165	17 August–20 September	–	–	–	–	6	129.2[a]	23.1	84–175
	18 September–27 October	–	–	–	–	6	140.2[b]	17.3	106–174	28 September–27 October	–	–	–	–	10	140.8[a]	20.1	101–180
	12 August–27 October	5	162.6[a]	19.0	–	–	–	–	–	8 August–27 October	7	158.1[b]	10.5	–	–	–	–	–
	All	90	174.6	19.5	136–213	–	–	–	–	All	112	144.0	15.6	113–175	–	–	–	–

SD: standard deviation; CI: 95% confidence intervals of individual values.
*Within a population, values with same superscripts are not significantly different ($P > 0.05$) from each other.

October juveniles. Live-captured animals weighing < 113 g could be classified as juveniles; those weighing ≥ 113 g could be either adults or juveniles.

Comparison between adult populations

Mean weights of Camrose and Lacombe adults differed significantly ($F_{3,381} = 86.7$, $P < 0.005$). On average, Camrose males and females were heavier ($P < 0.005$) than those of Lacombe.

On average, adult males from Camrose and Lacombe were significantly ($P < 0.05$) heavier than adult males from other alfalfa fields or habitat types (Table 2). On average, adult females from Camrose were also significantly ($P < 0.05$) heavier than females from other habitat types and regions. The mean weight of Lacombe adult females was, however, similar ($P > 0.05$) to those of females inhabiting alfalfa fields in Saskatchewan and Colorado (May sample), and unspecified agricultural lands in central Alberta (Table 2).

The Camrose and Lacombe adult males and females were at least 25% heavier than males and females found in habitats other than alfalfa fields. They were more than twice as heavy as Northern Pocket Gophers captured in British Columbia (Table 2).

Discussion

In this study, the hypothesis that adults would be, on average, heavier than juveniles in late summer-early fall was validated. Adult females grow until 2 years old, and males continue to grow throughout their lifetime (Tryon 1947; Miller 1952; Howard and Childs 1959; Daly and Patton 1986). Even though young-of-the-year appeared as large as adults, they were approximately 6-7 months old in the fall, and their growth was not completed (Tryon 1947). On the other hand, body sizes of juveniles and adults vary considerably within the same habitat due to differential individual growth rates from a same litter or population (Tryon 1947; Daly and Patton 1986), age of the individuals (i.e., older juvenile *vs.* younger adult) (Hansen and Bear 1964), and time of year (Miller 1952; this study). All this may explain the marked overlap observed within juvenile populations from August to October, and between juveniles and adults, as reported in previous studies (Tryon 1947; Miller 1952; Hansen and Bear 1964).

This study, and previous work (Tryon 1947; Hansen and Reid 1973; Hansen and Bear 1964), showed that mean body weights of age and sex classes varied considerably within and between study areas. Therefore, it is unlikely that reliable body weight categories may be established to differentiate juveniles from adults. At best, confidence intervals for individual values may be cautiously used to recognize lighter juveniles and heavier adults. Using confidence intervals of individual values for juvenile and adult males in Camrose and Lacombe, I propose that, in late summer-early fall, live-captured animals weighing < 130 g would likely be juveniles. Individuals weighing > 180 g may be adults. Animals weighing between 130 and 180 g might be either juveniles or adults. In the case of females, animals weighing <110 g would likely be juveniles. Larger animals should be classified on the basis of the presence of an open pelvic girdle, i.e., the pubic bones are widely separated due to the permanent resorption of the symphysis at first pregnancy (Miller 1952).

Given the variability of body weight in pocket gophers, any criteria for aging based on weight will

TABLE 2. Mean weights of adult Northern Pocket Gophers reported in the scientific literature.

			Adult weights (g)					
			Males			Females		
Location	Habitat types	Period	*n*	$\bar{x}$	Standard deviation	*n*	$\bar{x}$	Standard deviation
Alberta	Unspecified agricultural land near Edmonton – MacDonald (1969)	Summer	43	133	14	37	138	20
British Columbia	Forb-orchard – Sullivan et al. (2001)	Summer 1982	28	69	2	23	68	2
	Old field-orchard – Sullivan et al. (2001)	Summer 1983	69	71	2	49	60	1
	Orchard – Sullivan et al. (2001)	Summer 1983	22	61	4	58	63	1
		Summer 1985	22	74	4	59	65	2
Colorado	Alfalfa field – Hansen (1960)	April	86	159	61	49	136	20
		May	58	158	15	36	135	20
		June	18	148	21	25	136	16
		August	9	158	19	22	135	19
		September	9	176	17	12	158	11
	Alpine tundra – Hansen and Bear (1964)	August	14	114	8	34	106	12
	Meadow – Hansen and Bear (1964)	August	8	134	18	29	108	12
	Shrub-bunchgrass – Hansen and Bear (1964)	August	8	116	12	30	105	12
	Weedy rangeland – Hansen and Ward (1965)	August	37	127	13	46	114	14
Saskatchewan	Alfalfa field – Runnells (1988)	Summers 1983 and 1984	32	158	41	71	141	63
Utah	Coniferous forest – Andersen (1978)	June-October	5	104	3	14	91	2

have to be derived for local populations in specific habitat types. Body weight confidence intervals determined in this study may be useful to researchers working on Northern Pocket Gophers in central Alberta alfalfa fields. These confidence intervals would not be reliable to age live-captured animals from meadows, old field or orchard populations. Habitat differences in nutritional quality of available food can directly affect the observed variation in body weight among populations of pocket gophers (Smith and Patton 1980; Patton and Brylski 1987). Alfalfa is a superior forage producing more protein per ha than any other crop or grass (Heath et al. 1973). Northern Pocket Gophers inhabiting Camrose and Lacombe alfalfa fields were heavier than animals from other habitat types. A difference in the quality of food available in pure and mixed alfalfa fields may also explain the difference in the mean weights of Northern Pocket Gophers inhabiting Camrose and Lacombe.

Acknowledgments

I thank Pam Cole, Joel Nicholson, Nicole Proulx, Orest Litwin and Paul King for technical support, and Pauline Feldstein for reviewing an earlier draft. I am especially grateful to referee David Nagorsen for providing an insightful review of an earlier draft of this paper.

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Received 30 November 2004
Accepted 6 October 2005

Protocole de suivi des populations d'aster du Saint-Laurent, *Symphyotrichum laurentianum*, aux Îles-de-la-Madeleine

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de Lafontaine, Guillaume. 2005. Protocole de suivi des populations d'aster du Saint-Laurent, *Symphyotrichum laurentianum*, aux Îles-de-la-Madeleine. Canadian Field-Naturalist 119(4): 556-568.

L'aster du Saint-Laurent (*Symphyotrichum laurentianum* (Fernald) Nesom) est une plante endémique à la région du golfe du Saint-Laurent et on ne la retrouve qu'au Nouveau-Brunswick, à l'Île du Prince-Édouard ainsi qu'aux Îles-de-la-Madeleine, au Québec. Les populations les plus nombreuses se retrouvent aux Îles-de-la-Madeleine. L'espèce est considérée «préoccupante» par le COSEPAC depuis avril 1989 puis menacée depuis 2004. De nombreuses études réalisées par des équipes distinctes depuis 1988 ont tenté de recenser l'effectif et la superficie des populations réparties sur l'aire de distribution. Ces études étant réalisées par différentes équipes utilisant des méthodes distinctes pour mener les évaluations ont conduit à des résultats contrastants. Une revisite des occurrences connues aux Îles-de-la-Madeleine en septembre 2004 visait à mettre à jour l'état des connaissances sur la localisation exacte et l'effectif des populations d'aster sur l'archipel. Aussi, un protocole de suivi simple a été élaboré sur place, à partir duquel le personnel de l'organisme Attention Frag'Îles pourra récolter les données dans le futur. Ces données pourront ensuite être cumulées et interprétées facilement par ministère développement durable environnement et parcs du Québec pour effectuer le suivi à long terme. La méthodologie, ainsi uniformisée, permettra de décrire les variations temporelles de l'état des populations en s'assurant qu'elles ne sont pas obscurcies par différentes méthodes de prise de données.

Mots clés : Aster du Saint-Laurent, *Aster laurentianus*, *Symphyotrichum laurentianum,* espèce endémique, espèce menacée, espèce rare, espèce vulnérable, golfe du Saint-Laurent, Îles-de-la-Madeleine, suivi de populations.

L'aster du Saint-Laurent est une plante endémique de la région du golfe du Saint-Laurent. On la retrouve au Nouveau-Brunswick, à l'Île du Prince-Édouard et au Québec autour des lagunes sur l'archipel des Îles-de-la-Madeleine. Puisque son aire de distribution est très limitée et qu'elle n'est répartie qu'en petites populations, l'espèce a d'abord été considérée comme «préoccupante» par le COSEPAC en avril 1989, puis son statut a été réexaminé en mai 2004 pour la désigner «menacée» (COSEPAC 2004). Ainsi, quoique décrite pour la première fois en 1914 par Fernald, les études sur la localisation et l'effectif des différentes populations n'ont véritablement débuté qu'en 1988. Depuis, différentes équipes de recherche ont étudié la situation démographique de l'aster.

Un premier rapport sur le statut de l'aster du Saint-Laurent au Canada a établi les populations et leurs effectifs estimés entre 1983 et 1986 (Houle and Haber 1990). Les informations ultérieures proviennent de relevés effectués à l'Île du Prince-Édouard en 1992 et 1993 (Guignion et al. 1995) et aux Îles-de-la-Madeleine en 1994 et 1995 (Gagnon et al. 1995a, 1995b). À partir de la comparaison des résultats des études mentionnées ci-haut, Gilbert et al. (1999) soulignaient une fluctuation importante de la taille des populations dans le temps et attribuaient cette variation à la dynamique des perturbations naturelles ou anthropiques de l'habitat. Or, un troisième relevé effectué aux Îles-de-la-Madeleine entre 1999 et 2001 concluait que les populations d'aster du Saint-Laurent étaient relativement stables et fluctuaient peu d'une année à l'autre en absence de perturbations anthropiques (Houle et al. 2002). Enfin, suite à un relevé effectué en 2003, Duclos notait que l'aster était en déclin sur la totalité de son aire de répartition (Duclos 2004).

Ainsi, aux Îles-de-la-Madeleine, où l'on retrouve les plus grands effectifs, il y a eu quatre relevés depuis 1983. Ces quatre relevés menés par quatre équipes distinctes présentent des résultats contrastant que les auteurs interprètent différemment. Certains concluent que les populations fluctuent beaucoup (Gilbert et al. 1999; Duclos 2004), alors que d'autres, au contraire, concluent que les populations sont dans un état stable (Houle et al. 2002). On note cependant plusieurs lacunes concernant les méthodologies d'échantillonnage au sein de toutes ces études. Ainsi, ce qui constitue une population pour l'un est divisé en de nombreuses populations pour l'autre et chacun utilise sa propre numérotation pour désigner des populations définies de façon arbitraire. Aussi, les visites sur le terrain ont été effectuées à différents moments durant la saison de croissance. Sachant que l'aster est une espèce annuelle, la phénologie peut donc s'avérer d'une importance capitale pour l'estimation de la taille des populations. Pour définir l'emplacement des populations, certains utilisent des photos aériennes, une méthode rapide et pratique mais inexacte, alors que d'autres utilisent une seule coordonnée géoréférencée pour indiquer une population pouvant couvrir une superficie de plusieurs kilomètres. Dans d'autres cas, la seule information est un

point sur une carte grossière. Par conséquent, la localisation et l'effectif des populations demeurent équivoques.

La présente étude avait pour but d'uniformiser la récolte de l'information sur l'aster du Saint-Laurent, afin de permettre au ministère du développement durable, environment et parcs du Québec de suivre à long terme les variations temporelles de l'état des populations en s'assurant qu'elles ne sont pas obscurcies par différentes méthodes de prise de données. L'organisme local Attention Frag'Îles a été mandaté par le ministère du développement durable, environment et parcs afin d'assurer la collecte annuelle des données aux Îles-de-la-Madeleine.

Les objectifs spécifiques de la présente étude sont :

(1) Mettre à jour les données sur les effectifs, les localisations et les superficies des populations d'aster du Saint-Laurent aux Îles-de-la-Madeleine en 2004.

(2) Élaborer un protocole d'échantillonnage simple afin de permettre un suivi à long terme. Ce protocole a été remis au personnel d'Attention Frag'Îles basé aux Îles-de-la-Madeleine qui effectuera la récolte des données annuellement. Les données seront remises au ministère de du développement durable, environment et parcs du Québec qui assurera le suivi à long terme.

(3) Décrire la situation actuelle des populations sélectionnées pour le suivi.

Espèce

Symphyotrichum laurentianum (Fernald) Nesom est une plante halophyte annuelle, pratiquement glabre et dont la taille varie de 2 à 50 cm de hauteur. La tige est simple lorsque la densité est élevée ou ramifiée lorsque la densité diminue (observation personnelle). Les feuilles sont sessiles et entières, parfois un peu charnues. Les fleurs sont regroupées en capitules entourés de bractées foliacées. Un capitule est présent à chaque ramification de la tige. Les premières plantules émergent à la fin de mai et les premières inflorescences apparaissent au début du mois d'août alors que les fruits (akènes) matures sont disséminés par le vent vers la fin de septembre.

Aux Îles-de-la-Madeleine, l'espèce se retrouve typiquement sur une bande de ca. 50 à 200 cm de largeur en périphérie des lagunes et des marais salés (Houle et al. 2001). Cette répartition limitée est due à une dynamique particulière. Près de la rive, l'émergence de l'aster est limitée par la salinité (Houle et al. 2001, Reynolds et al. 2001; Reynolds et Houle 2002). La distribution près du rivage est également affectée par l'exposition aux vents, aux vagues lors de tempêtes, aux fortes marées d'équinoxe et aux dépôts de débris, surtout constitués de zostère (*Zostera marina* L.). Ce gradient de salinité et de perturbations physiques diminue en s'éloignant du rivage, favorisant ainsi la croissance de différentes espèces. Il a de plus été démontré expérimentalement que le taux de croissance relatif de l'aster du Saint-Laurent diminue lorsque la plante est placée à l'ombre (Reynolds et al. 2001; Houle et Valéry 2003). Ainsi, l'aster est rapidement remplacé par d'autres espèces plus compétitrices lorsque les conditions permettent la croissance de ces dernières (Brumbt 2001). Il s'agit donc d'une espèce tolérante à un certain niveau de stress (salinité, inondations, dépôts de zostère, vents) qui restreint les autres espèces plus compétitrices (Grime 1977, 1979).

Méthodes

Mise à jour des données sur les effectifs, les localisations et les superficies des populations

Les 25 stations de Houle et al. (2002) où l'aster était présent (entre 1999 et 2001) et une station recensée par Gagnon et al. (1995b) mais non visitée par Houle et al. ont été revisitées du 8 au 16 septembre 2004, soit pendant la période de floraison / fructification. Ce relevé inclut donc toutes les dernières populations recensées, mais exclut les occurrences historiques. Les populations ont été renommées selon des critères géographiques plutôt que numérotées arbitrairement comme dans plusieurs études précédentes. Ceci a pour but d'uniformiser la nomenclature et de classer les populations selon un critère fixe plutôt que sur une base potentiellement variable tel que la distance entre deux occurrences. L'effectif de chaque population a d'abord été estimé visuellement et une classe sur une échelle logarithmique de 0 à 6 a été attribuée à la population (*classes* : *0* aucun individu retrouvé; *1* – 1 à 10 individus; *2* – 10 à 100 individus; *3* – 10^2 à 10^3 individus; *4* – 10^3 à 10^4 individus; *5* – 10^4 à 10^5 individus; *6* – 10^5 à 10^6 individus). La localisation exacte de l'ensemble de la superficie couverte par chaque population a été définie par des coordonnées géoréférencées à l'aide d'un GPS.

Élaboration d'un protocole de suivi simple

Les trois populations ayant les effectifs les plus importants ont été sélectionnées aux fins du programme de suivi. Pour chacune des trois populations, cinq transects permanents ont été installés perpendiculairement à la ligne du rivage. Les cinq transects ont été répartis dans l'ensemble de la population de façon à couvrir l'ensemble des conditions environnementales permettant la croissance de l'aster. Tous les transects ont une dimension de 3 m de longueur par 1 m et sont divisés en six quadrats de 0.5 m par 1 m. Ainsi, chaque transect couvre la largeur de la bande d'aster typiquement retrouvée le long des lagunes. Le premier quadrat se trouve près de la ligne d'eau dans le milieu plus perturbé et le dernier quadrat est situé à travers la végétation, dans le milieu plus compétitif.

Les mesures devront être prises annuellement, entre la deuxième semaine de août et la troisième semaine de septembre, soit pendant la période de floraison de l'aster. Dans chaque quadrat, huit variables importantes devront être mesurées : (1) le nombre de tiges d'aster; (2) le pourcentage de couverture par l'aster; (3) le pour-

TABLEAU 1. Liste des occurrences d'aster du Saint-Laurent aux Îles-de-la-Madeleine en 2004 en comparaisons avec les effectifs observés dans les études précédentes. Les nombres entre parenthèses à droite du nom des populations réfèrent aux stations de Houle et al. (2002). Les chiffres en caractères gras indiquent la classe attribuée à la population dans la présente étude.

Nom de la population	Nombre d'individus			
	Présente étude	Duclos (2004)	Houle et al. (2002)	Gilbert et al. (1999)
Cap de l'hôpital (11 et 12)	**4** - 10^3 à 10^4	10^3 à 10^4	10^2 à 10^5	10^4 à 10^5
Barachois, Chemin Poirier (8 et 10)	**1** - 1 à 10	10^5 à 10^6	1 à 1000	
Barachois (9)	**5** - 10^4 à 10^5		10^5 à 10^6	
Étang du nord (13)	**0** - aucun aster	Non revisitée	1 à 1000	10^5 à 10^6
Havre aux Basques (14)	**5** - 10^4 à 10^5	10^4 à 10^5	+ de 10^6	
Pointe des véliplanchistes (15, 16 et 17)	**3** - 10^2 à 10^3	Non revisitée	10^4 à 10^6	
Pointe aux canots (18)	**3** - 10^2 à 10^3	10^2 à 10^3	10^5 à 10^6	
Dune de l'ouest (19)	**3** - 10^2 à 10^3	Non revisitée	10^6 à 10^7	
Étang des caps (20)	**6** - 10^5 à 10^6	Non revisitée	10^6 à 10^7	
Baie du portage	**1** - 1 à 10	Non revisitée	Non revisitée	
Baie de Grosse Ile (43 et 44)	**5** - 10^4 à 10^5	Non revisitée	10^3 à 10^4	Non connue
Baie Clarke (31)	**4** - 10^3 à 10^4	Non revisitée	10^3 à 10^4	10 à 100
Pointe Old Harry (6)	**0** - aucun aster	Non revisitée	10 à 100	0 à 1000
Bassin aux Huîtres, Bassin est (4 et 5)	**3** - 10^2 à 10^3	0	10^3 à 10^6	10^5 à 10^6
Bassin aux Huîtres, Club vacance (34)	**2** - 10 à 100	0	10 à 100	
Bassin aux Huîtres, centre (33)	Non revisitée	0	1 à 100	
Bassin aux Huîtres, Bassin ouest (2 et 3)	**3** - 10^2 à 10^3	10^3 à 10^4	10^1 à 10^6	
Pointe de l'est (23 et 24)	Non revisitée	Non revisitée	10 à 100	10 à 100

centage de couverture par toute la végétation; (4) le pourcentage de couverture des dépôts de zostère; (5) le pourcentage de couverture de sol nu; (6) la hauteur de la plus haute tige d'aster; (7) le nombre de capitules de la tige d'aster la plus ramifiée; (8) la richesse spécifique. Ces variables sont faciles à récolter, ne nécessitent aucun instrument de mesure autre qu'un ruban à mesurer et sont rapidement accessibles. Cependant, les mesures devront idéalement être effectuées par un observateur unique puisque les variables de recouvrement sont évaluées par estimation visuelle et sont donc sujettes à changer selon l'observateur. Les variables sélectionnées donnent un indice de l'effectif, la densité, l'habitat et la morphologie de la population à l'étude.

Description de la situation actuelle aux populations sélectionnées pour le suivi

Les mesures aux trois populations ont été prises selon la méthode décrite à l'objectif précédent entre le 16 et le 21 septembre 2004. Les analyses statistiques ont été effectuées à l'aide du logiciel Statistica release 5 (StatSoft, Tulsa, Oklahoma, USA). Il est à noter que les variables pourcentage de couverture du dépôt de zostère et pourcentage de couverture de sol nu n'ont pas été utilisées dans les analyses. Ces variables fournissent un indice de l'habitat, mais ne seront pas discutées en détail.

Une analyse de variance nichée de modèle II pur (*pure Model II nested ANOVA*) où le facteur transect est niché dans le facteur population a été effectuée (Sokal et Rohlf 1969). Ceci permet de déceler l'existence de véritables différences entre les populations d'une part et les cinq transects de chaque population d'autre part. Pour toutes les variables générant des résultats significatifs ($\alpha = 0.05$), une comparaison des moyennes à l'aide du test Tukey HSD a été effectuée entre les populations.

Les données des trois populations ont ensuite été analysées pour vérifier l'existence d'une relation entre chaque variable et l'éloignement par rapport à la ligne d'eau. La meilleure régression, linéaire ou quadratique, a été sélectionnée à chaque population et pour chaque variable afin d'expliquer la relation. Les critères de sélection pour la meilleure régression était la puissance du coefficient de régression, le raisonnement de l'interprétation mathématique et la signification biologique.

Résultats

Mise à jour des données sur les effectifs, les localisations et les superficies des populations

L'aster était présent à toutes les stations revisitées sauf deux. De plus, deux stations n'ont pas été revisitées dû aux contraintes de temps (*Pointe de l'Est*) et à l'établissement d'une résidence privée (*Bassin aux huîtres – secteur centre*). Le tableau 1 présente les populations et leurs effectifs en comparaison des occurrences notées dans Duclos (2004), Houle et al. (2002) et Gilbert et al. (1999). Les études de Houle et Haber (1990) et Gagnon et al. (1995a, 1995b) sont incluses dans Gilbert et al. (1999).

Premièrement, il est à noter que l'étude de Houle et al. (2002) divise les populations (25 stations) alors que Gilbert et al. (1999) tend à les regrouper (8 occurrences). Duclos (2004) a utilisé la numérotation de Houle et al. (2002). La présente étude propose une nouvelle définition des populations issues des stations de

Houle et al. (2002). Quelques stations qui n'étaient pas clairement divisées sur le terrain ont été regroupées. Ainsi, l'étude actuelle définit 18 populations nommées selon des références géographiques plutôt que numérotées arbitrairement. Les informations relatives à chaque populations sont présentées ci-après:

Cap de l'hôpital
Classe 4 (± 1500 individus)
Localisation : N 47°25.112' et N 47°25.100'
W 61°53.808' W 61°53.933'
Cette population a décliné depuis les premières observations de Houle et al. (2002). Un ensablement du site a entraîné une diminution considérable de l'effectif en 2001. Les observations récentes (Duclos 2004 et cette étude) montrent que la population a survécu à cette perturbation, mais que son effectif n'est pas encore retourné aux valeurs déjà observées.

Barachois, Chemin Poirier
Classe 1 (4 individus)
Localisation : N 47°25.180'
W 61°51.971'
Petite population spatialement distincte de la grande population *Barachois*. Seulement quelques individus répartis très localement. Houle et al. (2002) ont observé une population de classe 3 en 1999 et 2000, alors qu'en 2001 la population était de classe 2. Ce présent relevé note une population de classe 1. Ainsi, cette population montre une tendance continuelle au déclin depuis les premières observations.

Barachois
Classe 5 (± 63 000 individus)
Localisation : N 47°25.440' à N 47°25.365'
W 61°52.015' W 61°51.689'
La population commence au bout d'un chemin (début de la grande plage) et est présente dans les premiers mètres de végétation à l'interface entre la grande plage et le barachois. La population démontre une grande variabilité phénotypique. À la pointe du barachois les individus sont plus hauts et ramifiés et sont répartis en tiges isolées. Vers le début de la grande plage, les individus sont petits, peu ramifiés et regroupés en touffes denses. L'habitat est soumis à des perturbations naturelles (inondation, ensablement) et anthropiques (VTT — véhicules tout-terrain). En comparaison avec les études précédentes, l'ordre de grandeur de cette importante population apparaît relativement stable. Gilbert et al. (1999) décrivait une population de classe 5, alors que Houle et al. (2002) et Duclos (2004) l'ont classée 6. Dans la présente étude, la population est reclassée 5. Cette population a peut-être été sous-évaluée ou surévaluée en raison de la difficulté d'estimation due à la superficie et l'effectif considérables. Ainsi, en l'absence d'une tendance continue entre les études, il est difficile de poser des conclusions quant à la dynamique de cette population. Le protocole de suivi à long terme inclura ce site afin de déterminer si les différences observées proviennent de différentes méthodes d'estimation ou de tendances réelles.

Étang du Nord
Classe 0, aucun individu retrouvé à ce site (station 13 de Houle et al. (2002)). En 2001, Houle et al. (2002) ont constaté un déclin de cette population qui passait de la classe 3 à la classe 1. Trois ans plus tard, il est possible que cette population ait décliné jusqu'à l'extinction.

Havre aux Basques
Classe 5 (± 64 000 individus)
Localisation : N 47°18.394' à N47°17.465'
W 61°56.329' W61°56.080'
La population est répartie en deux zones le long de la lagune. Dans la première zone, quelques tiges isolées sont retrouvées dans les sites favorables. Le littoral est tranché par l'érosion et les dépôts de zostère à plusieurs endroits ce qui diminue le nombre de sites favorables à l'établissement de l'aster. La seconde zone compte une plus grande densité d'individus et est caractérisée par des tiges plus ramifiées et plus hautes. Le milieu est apparu moins perturbé. Ici encore, les estimés ne sont pas constants entre les études et aucune tendance ne peut être décelée. Comme la population du *Barachois*, celle-ci sera inclue dans le suivi.

Pointe des véliplanchistes
Classe 3 (± 200 individus)
Localisation : N47°16.928' à N47°15.816'
W61°55.808' W61°55.632'
La population peu nombreuse couvre une vaste étendue très perturbée par les inondations. Par rapport à la seule autre étude qui traite spécifiquement de cette population (Houle et al. 2002), l'effectif a diminué considérablement passant d'une population de classe 6 à une population de classe 3. Ceci indique un changement certain de l'effectif de cette population indépendant des méthodes utilisées pour l'estimation. Cependant, puisque aucune autre étude ne s'attarde spécifiquement à cette population, on ne peut déterminer s'il s'agit d'une véritable tendance au déclin.

Pointe aux canots
Classe 3 (± 100 individus)
Localisation : N47°15.959' à N47°16.016'
W61°58.569' W61°58.694'
La petite population est soumise à des perturbations (inondation, dépôt de zostère). Lors d'une comparaison entre les sites de *Pointe aux canots* et *Havre aux Basques*, Reynolds et Houle (2002) observaient que la population de *Pointe aux canots* était dans une baie protégée. Cependant, lors du relevé de 2004, j'ai pu observer que de nombreux individus étaient ensevelis sous d'épais dépôts de zostère. L'essentiel de la végétation croissait immédiatement après la ligne d'eau sur le littoral, ne laissant que peu de micro-sites favorables à l'établissement de l'aster. L'étude de Houle et al. (2002) comptait beaucoup plus d'individus que l'étude de Duclos (2004) et la présente étude. En effet, selon Houle et al. (2002), la population était de classe 6 alors que les relevés suivants présentent une population de classe 3. Tel que mentionné pour la population précédente, ceci indique un changement certain de l'effectif indépendant des méthodes utilisées pour l'estimation. De plus, puisque la diminution est constante au cours de deux études subséquentes, il semble que la population soit en déclin.

Dune de l'ouest
Classe 3 (± 100 individus)
Localisation : N47°19.429' à N47°19.377'
W61°57.448' à W61°57.482'
L'étude de Houle et al. (2002) recensait plus de 2 millions d'individus dans cette population et l'occurrence polygonale notée par le centre de données sur le patrimoine naturel du Québec (CDPNQ) (Gagnon et al. 1995b) était de superficie considérable. Or, en 2004, seulement une centaine d'individus

ont été retrouvés regroupés dans une zone très restreinte. Le milieu ne présente pas une inclinaison importante et il s'agit plutôt d'une vaste plaine hautement productive. Lors de la visite, toute cette plaine était inondée et des espèces parfois retrouvées en compétition avec l'aster et non aquatiques (e.g., potentille ansérine, *Potentilla anserina* L.) étaient submergées. Par conséquent, l'habitat propice à la croissance de l'aster n'était que peu présent sur le site. Il est encore une fois difficile d'observer une tendance continue puisque seule l'étude de Houle et al. (2002) sert de point de comparaison pour cette population. Cependant, une diminution allant de plus de deux millions à seulement une centaine d'individus est jugée substantielle et même dramatique. Un autre relevé devrait être effectué dans les prochaines années afin de suivre l'état de cette population.

Étang des caps
Classe 6 (± 240 000 individus)
Localisation : N47°16. 598' à N47°16.690'
W61°59.155' W61°58.416'
L'essentiel de cette population est situé sur un îlot dans la lagune du Havre aux Basques accessible à gué. Depuis l'étude de Houle et al. (2002), la population est caractérisée par un effectif très élevé. De toutes les populations visitées, celle-ci est présente l'effectif le plus important.

Baie du portage
Classe 1 (8 individus)
Localisation : N47°15.381'
W61°56.423'
Cette population n'avait pas été revisitée depuis l'étude de Gagnon et al. (1995b) où l'effectif exact n'était pas indiqué. Le relevé de 2004 constitue donc la première évaluation de l'effectif de cette petite population.

Baie de Grosse-Île
Classe 5
Localisation : N47°37.366' à N47°37.428'
W61°32.401' à W61°32.434'
La population est située le long d'un sentier de VTT. Le gradient de perturbation / compétition est donc entretenu par le passage récurrent de VTT. L'effectif de cette population a augmenté depuis la dernière observation par Houle et al. (2002). Il est possible que la popularité des VTT sur Grosse-Île (Alain Richard. Attention Frag'Îles, communication personnelle) encourage la croissance démographique de la population d'aster par le passage de nombreux appareils.

Baie Clarke
Classe 4 (± 1000 individus)
Localisation : N47°37.394' à N47°37.358'
W61°28.331' W61°28.368'
Cette population est également située le long d'un sentier de VTT et les sites favorables sont entretenus par leur passage récurrent. La population est stable depuis l'étude de Houle et al. (2002) et l'effectif a augmenté depuis les premières observations en 1995 (Gilbert et al. 1999).

Pointe Old-Harry
Classe 0. Bien que l'habitat semble propice, aucun individu n'a été retrouvé à ce site (station 6 de Houle et al. (2002)). Le suivi de Houle et al. (2002) notait une population stable de classe 2. Après une recherche exhaustive autour de la coordonnée géoréférencée fournie dans Houle et al. (2002), aucun individu n'a été retrouvé. Houle et al. (2002) notaient que l'ensemble de la végétation était fauchée pour entretenir un espace de stationnement, il est possible que la taille continuelle de cette plante annuelle a empêché l'établissement du stade adulte reproducteur menant ainsi cette petite population à l'extinction.

Bassin aux Huîtres, bassin est
Classe 3 (± 500 individus)
Localisation : N47°33.543'
W61°30.304'
La population se trouve dans le gravier du stationnement. Houle et al. (2002) avait noté la présence de nombreuses tiges d'aster, constituant l'essentiel de la population près d'un étang. Aujourd'hui, l'étang s'est eutrophié et les algues vertes ont envahi les sites favorables à l'aster. La tendance à l'eutrophisation avait débuté lors du dernier relevé de Houle et al. (2002) (Gilles Houle, communication personnelle). Dans la présente étude, aucun aster n'a été retrouvé près de l'étang. Duclos (2004) avait concentré l'effort d'échantillonnage près de cet étang et n'avait pas noté la présence de l'aster dans le gravier (Geneviève Duclos, communication personnelle). La perte de cette partie de la population a entraîné un déclin, l'ensemble de la population passant de la classe 6 (Houle et al. 2002) à la classe 3 en 2004.

Bassin aux Huîtres, club vacance
Classe 2 (± 50 individus)
Localisation : N47°33.366'
W61°30.936'
Les individus de cette population croissent à travers les galets d'une mise à l'eau pour embarcations nautiques. La population a conservé l'effectif noté par Houle et al. (2002).

Bassin aux Huîtres, centre
La population n'a pas été revisitée, une habitation privée avait été bâtie à proximité de la station de Houle et al. (2002). Cependant, lors du dernier relevé de Houle et al. (2002), il ne restait qu'un seul individu et Duclos (2004) n'en a noté aucun. Il est donc très possible que cette population soit maintenant éteinte.

Bassin aux Huîtres, bassin ouest
Classe 3 (± 500 individus)
Localisation : N47°32.613' à N47°32.656'
W61°31.848' W61°31.946'
Les individus sont répartis le long d'une bande à l'interface entre un milieu dunaire et une zone fréquemment inondée. La population semble en déclin continuel. Gilbert et al. (1999) et Houle et al. (2002) notaient une population de classe 6; dans Duclos (2004) elle passait vers la classe 4 et dans la présente étude une population de classe 3 est observée. Houle et al. (2002) ont noté une forte érosion de l'habitat de l'aster et une diminution importante en 2001 ne laissant qu'une population de classe 2. Il est donc possible que cette population soit soumise à de fortes perturbations cycliques et que l'effectif de cette population soit très variable.

Pointe de l'est
Cette population n'a pas été revisitée

Élaboration d'un protocole de suivi simple
Les trois populations retenues pour l'élaboration du protocole de suivi sont *Barachois* (BAR), *Havre aux Basques* (HAB) et *Étang des caps* (EDC). Les localisations exactes de chaque transect permanent ont été identifiées à l'aide d'un GPS et sont présentées au tableau 2.

TABLEAU 2. Localisations des 15 transects permanents installés aux trois populations sélectionnées pour le suivi à long terme.

Population	Transect	Latitude	Longitude
Barachois (BAR)	BAR1	N 47°25.369'	W 61°51.682'
	BAR2	N 47°25.400'	W 61°51.703'
	BAR3	N 47°25.432'	W 61°51.763'
	BAR4	N 47°25.448'	W 61°51.962'
	BAR5	N 47°25.442'	W 61°52.012'
Havre aux Basques (HAB)	HAB1	N 47°18.388'	W 61°56.332'
	HAB2	N 47°18.245'	W 61°56.290'
	HAB3	N 47°17.791'	W 61°56.212'
	HAB4	N 47°17.732'	W 61°56.250'
	HAB5	N 47°17.686'	W 61°56.241'
Étang des caps (EDC)	EDC1	N 47°16.707'	W 61°58.905'
	EDC2	N 47°16.719'	W 61°58.877'
	EDC3	N 47°16.717'	W 61°58.871'
	EDC4	N 47°16.702'	W 61°58.764'
	EDC5	N 47°16.687'	W 61°58.626'

Description de la situation actuelle aux populations sélectionnées pour le suivi

Des différences significatives entre les populations ont été notées pour toutes les variables à l'étude (Tableau 3). Aussi, pour quatre des six variables étudiées, il existe des différences entre les cinq transects d'une même population. L'absence de différence significative pour les deux autres variables serait attribuable au manque de degrés de liberté associé au modèle contenant de nombreuses données manquantes. En effet, il n'y avait aucune valeur de hauteur ou de nombre de capitules associés aux quadrats où il n'y avait pas d'aster. La figure 1A montre que la population *Étang des caps* (EDC) est la plus dense (40.00 ± 6.23 tiges d'aster / 0.5 m^2) et est significativement supérieure à celle de *Havre aux Basques* (HAB) (8.90 ± 2.00 tiges d'aster / 0.5 m^2). La population *Barachois* (BAR) n'est pas différente des deux autres avec une valeur intermédiaire (21.90 ± 10.51 tiges d'aster / 0.5 m^2). La figure 1B montre que la population *Étang des caps* a un pourcentage de couverture par l'aster significativement supérieur (6.00 ± 0.98 %) par rapport aux deux autres sites (HAB : 2.60 ± 0.62 % et BAR : 1.33 ± 0.40 %). Cependant, à la figure 1C, on constate que la population *Étang des caps* a un pourcentage de couverture par l'ensemble de la végétation inférieur (16.77 ± 2.75 %) par rapport aux deux autres populations (HAB : 52.57 ± 5.96 % et BAR : 64.57 ± 6.70 %). La hauteur des tiges d'aster ainsi que le nombre de capitules par individu présentent le même patron de variation entre les trois sites (Figures 1 D et E) : *Havre aux Basques* a les valeurs les plus élevées (respectivement 18.86 ± 1.08 cm et 48.50 ± 8.10 capitules par plant). *Étang des caps* a des valeurs intermédiaires significativement différentes des deux autres populations (respectivement 11.63 ± 0.74 cm et 25.93 ± 3.17 capitules par plant). Enfin, *Barachois* a les valeurs les plus basses (respectivement 8.41 ± 0.84 cm et 6.12 ± 1.41 capitules par plant). Enfin, la figure 1F montre que la richesse spécifique est plus élevée à *Havre aux Basques* (7.17 ± 0.59 espèces /

TABLEAU 3. Résultats de l'ANOVA nichée pour évaluer les différences inter-populations et inter-transects pour les variables. Les valeurs *P* en caractères gras sont significatives.

\Variables	Facteurs	Valeurs *F*	Valeurs *P*
Nombre de tiges d'aster	Population	6.098	**0.0035**
	Transect (population)	3.039	**0.0016**
Pourcentage de couverture par l'aster	Population	15.069	**<0.0001**
	Transect (population)	3.227	**0.0009**
Pourcentage de couverture par la végétation	Population	42.529	**<0.0001**
	Transect (population)	8.377	**<0.0001**
Hauteur des tiges d'aster	Population	24.925	**<0.0001**
	Transect (population)	1.831	0.066
Nombre de capitules par aster	Population	9.612	**0.0003**
	Transect (population)	0.878	0.574
Richesse spécifique	Population	3.208	**0.046**
	Transect (population)	7.441	**<0.0001**

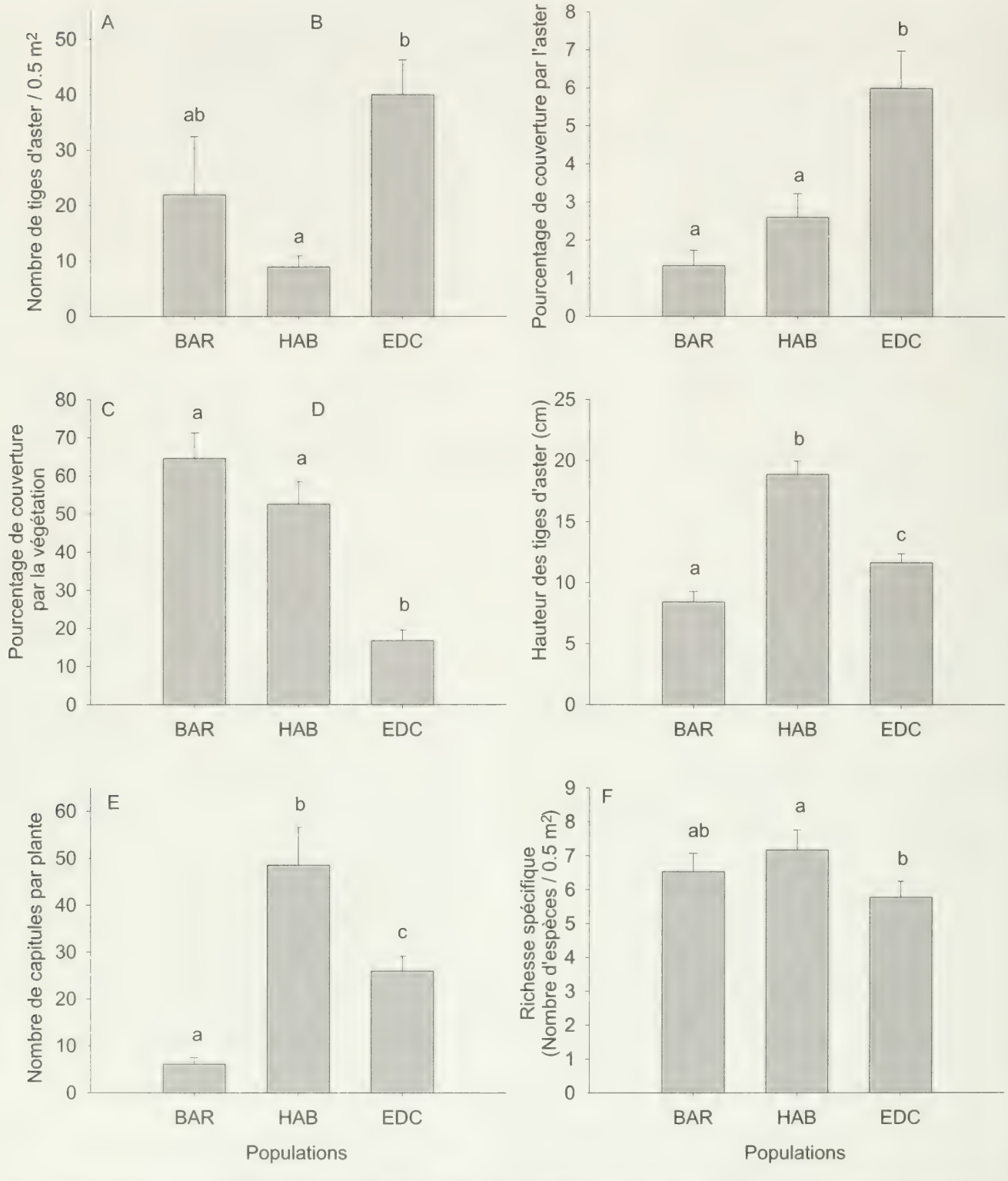

FIGURE 1. Variables à l'étude sur chacun des sites (moyenne par quadrat de 0.5 m² + SE). Les lettres différentes au-dessus des colonnes représentent des valeurs moyennes significativement différentes ($P \leq 0.05$) entre les sites.

0.5 m²) qu'à *Étang des caps* (5.77 ± 0.47 espèces / 0.5 m²), alors qu'elle est intermédiaire à la population *Barachois* (6.53 ± 0.54 espèces / 0.5 m²).

Quoique l'ANOVA nichée démontre qu'il existe des différences significatives entre les transects à chacun des sites et que ces transects ne peuvent donc être considérés comme de véritables réplicats, on observe des relations significatives entre les variables et la distance par rapport à la ligne du rivage pour les populations HAB et EDC (Figure 2). La population *Barachois* ne présente aucune tendance en fonction de la distance par rapport à la ligne du rivage. Les résultats complets sont présentés au tableau 4 et seules les régressions sélectionnées sont présentées dans le texte. Les figures 2A et B montrent que le nombre d'aster et le pourcentage de couverture d'aster varient de façon quadratique (respectivement, HAB $R^2 = 0.295$, $P = 0.09$ et EDC $R^2 = 0.218$, $P = 0.036$; HAB $R^2 = 0.292$, $P = 0.0095$ et EDC $R^2 = 0.280$, $P = 0.012$) avec un mode aux distances intermédiaires

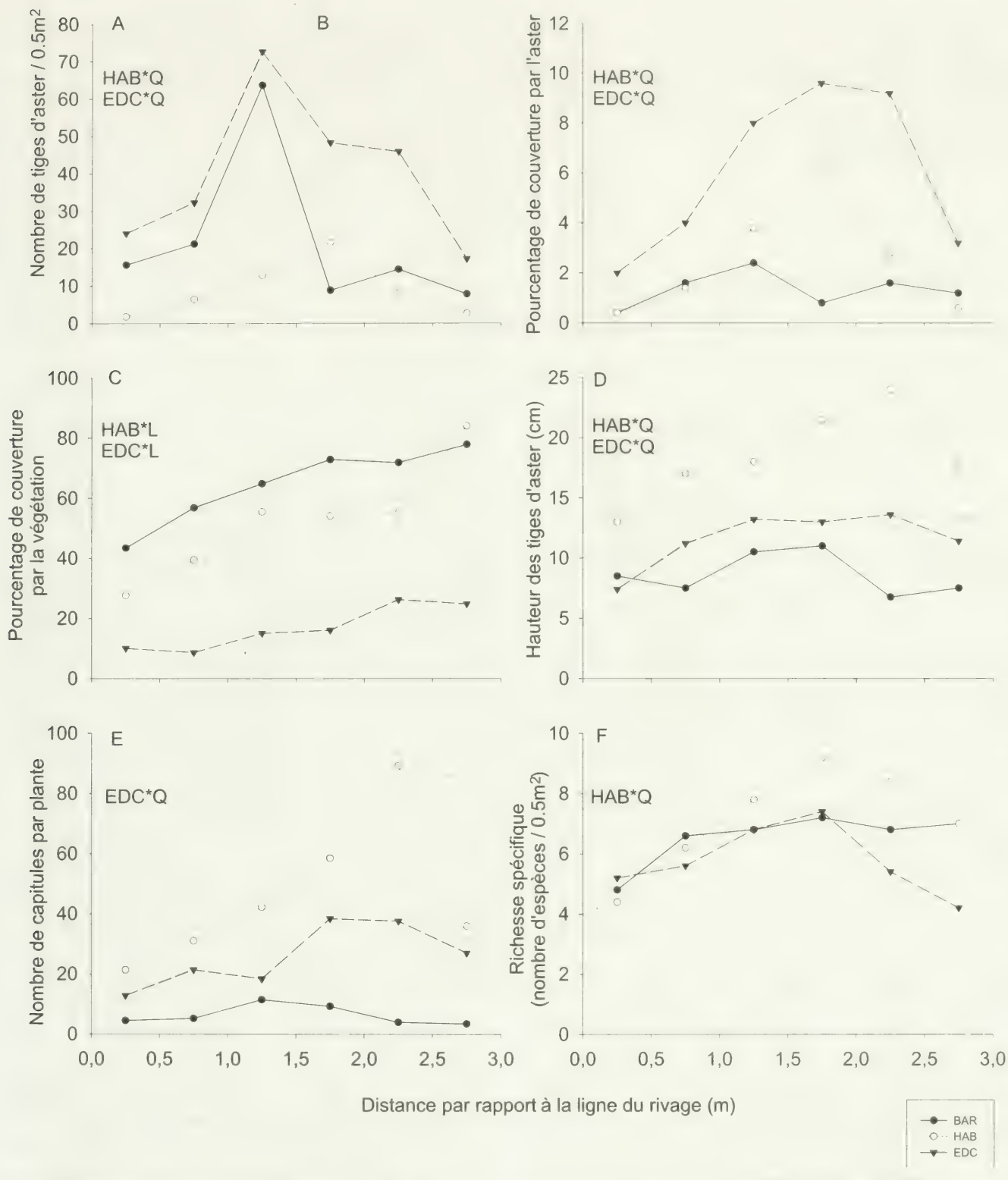

FIGURE 2. Variation des variables à l'étude le long du gradient topographique à chaque site. BAR*, HAB* ou EDC* indique une régression significative , suivie de L lorsque linéaire ou Q lorsque quadratique.

par rapport à la ligne du rivage (i.e. ces deux variables augmentent en s'éloignant du rivage pendant 1.5 m puis diminuent). Par contre, à la figure 2c, il est démontré que le pourcentage de couverture de l'ensemble de la végétation augmente de façon linéaire et positive en s'éloignant de la ligne du rivage (HAB $R^2 = 0.247$, $P = 0.0052$ et EDC $R^2 = 0.177$, $P = 0.021$). À la figure 2d, on voit que la hauteur des tiges d'aster varie de façon quadratique (HAB $R^2 = 0.358$, $P = 0.015$ et EDC $R^2 = 0.268$, $P = 0.015$). La figure 2e montre que le nombre de capitules varie aussi de façon quadratique à la population *Étang des caps* ($R^2 = 0.211$, $P = 0.041$), alors qu'à la figure 2f il est montré que la richesse varie de façon quadratique à *Havre aux Basques* ($R^2 = 0.232$, $P = 0.028$).

Discussion

Mise à jour des données sur les effectifs, les localisations et les superficies des populations

L'étude de Gilbert et al. (1999) regroupe toutes les populations entourant la lagune du Havre aux Basques (*Havre aux Basques*, *Pointe des véliplanchistes*, *Pointe*

TABLEAU 4. Régressions (linéaires : $y = \beta_1 x + \beta_0$; et quadratiques $y = \beta_2 x^2 + \beta_1 x + \beta_0$) des différentes variables (y) en fonction de la distance par rapport à la ligne du rivage (x). Les valeurs en caractères gras sont significatives ($P \leq 0.05$) et * indique que la régression a été sélectionnée lorsque les régressions linéaires et quadratiques étaient significatives.

Variables	Populations	Régression	Coefficients de régression (RÇ)	Valeurs *P*
Nombre de tiges d'aster	BAR	Linéaire	0.0097	0.605
		Quadratique	0.0366	0.605
	HAB	Linéaire	0.0063	0.676
		Quadratique	**0.295***	**0.009***
	EDC	Linéaire	0.0006	0.894
		Quadratique	**0.218***	**0.036***
Pourcentage de couverture par l'aster	BAR	Linéaire	0.0029	0.777
		Quadratique	0.0300	0.663
	HAB	Linéaire	0.0127	0.553
		Quadratique	**0.292***	**0.0095***
	EDC	Linéaire	0.045	0.257
		Quadratique	**0.280***	**0.012***
Pourcentage de couverture par la végétation	BAR	Linéaire	0.093	0.102
		Quadratique	0.101	0.238
	HAB	Linéaire	**0.247***	**0.0052***
		Quadratique	**0.249**	**0.021**
	EDC	Linéaire	**0.177***	**0.021***
		Quadratique	0.179	0.070
Hauteur de l'aster	BAR	Linéaire	0.0069	0.751
		Quadratique	0.0066	0.619
	HAB	Linéaire	**0.221**	**0.027**
		Quadratique	**0.358***	**0.015***
	EDC	Linéaire	0.110	0.074
		Quadratique	**0.268***	**0.015***
Nombre de capitules par plant	BAR	Linéaire	0.0071	0.748
		Quadratique	0.134	0.365
	HAB	Linéaire	0.131	0.098
		Quadratique	0.194	0.129
	EDC	Linéaire	**0.159**	**0.029**
		Quadratique	**0.211***	**0.041***
Richesse spécifique	BAR	Linéaire	0.04	0.290
		Quadratique	0.065	0.404
	HAB	Linéaire	0.104	0.083
		Quadratique	**0.232***	**0.028***
	EDC	Linéaire	0.0092	0.613
		Quadratique	0.142	0.126

aux canots, *Dune de l'ouest*, *Étang des caps* et *Baie du portage*). Or, une seule station de Houle et al. (2002; station 19) montre un effectif dix fois supérieur à celui observé pour l'ensemble des populations entourant la lagune regroupées dans Gilbert et al. (1999). Il est possible que Houle et al. aient surestimé les populations par rapport aux autres études puisque dans l'étude de Houle et al. (2002), tous les relevés ont été effectués alors que les individus étaient au stade végétatif. Par conséquent, il est possible que Houle et al. aient inclus des plantules n'ayant pas encore émergé. Toutes les autres études se déroulant au mois de septembre, pendant la floraison, rapportent des effectifs un peu plus faibles que ceux de Houle et al. (2002). Cependant, il paraît peu probable que cette différence dans la phénologie explique à elle seule une diminution aussi importante que celle observée, par exemple, à la population de la *dune de l'ouest* (de plus de 2 millions à une centaine d'individus). Dans un souci d'uniformiser les futurs inventaires, les relevés subséquents devraient être effectués après la deuxième semaine d'août et avant la troisième semaine de septembre afin de tenir compte uniquement des individus adultes ayant émergé.

Les études de Gagnon et al. (1995a, 1995b) citées dans Gilbert et al. (1999) ont été réalisées au cours d'une année dont la période de croissance (mai à septembre) était particulièrement sèche (Archives Nationales d'information et de données climatologiques (Environnement Canada) données utilisées aux stations de Gaspé et Charlottetown (IPE) disponibles sur www.climate.weatheroffice.ec.gc.ca; tableau 5). Une étude sur les effets du stress hydrique sur différents stades de croissance de l'aster a démontré qu'une sécheresse avait un effet négatif sur l'établissement des plantules (Houle et Belleau 2000). Par conséquent, il est possible que les études de Gagnon et al. (1995a, 1995b) aient eu lieu

TABLEAU 5. Tableau des données de pluviométrie mensuelle pour les saisons de croissance des années 1995 et 2004 et les moyennes mensuelles aux stations météorologiques de Gaspé et Charlottetown (IPE). Source : Archives Nationales d'information et de données climatologiques (Environnement Canada). ND indique que les données ne sont pas disponibles.

Site	Période	Pluviométrie mensuelle (mm)				
		mai	juin	juillet	août	septembre
Gaspé	1995	45.0	32.9	82.0	71.2	28.6
	2004	86.0	67.6	109.8	133.6	95.9
	Moyennes	90.8	73.4	107.7	91.2	70.0
Charlottetown (IPE)	1995	69.7	96.2	59.2	59.3	62,5
	2004	ND	ND	ND	ND	ND
	Moyennes	97.7	93.2	85.8	87.3	95.4

pendant une année où peu d'individus adultes avaient émergé entraînant des effectifs plus bas que la moyenne.

Au contraire, la présente étude s'est déroulée à la fin d'une saison de croissance où les précipitations ont été plus abondantes que la moyenne (Archives Nationales d'information et de données climatologiques (Environnement Canada) données utilisées à la station de Gaspé disponibles sur www.climate.weatheroffice.ec.gc.ca; tableau 5). Les niveaux d'eaux étant élevés, beaucoup de sites favorables à la croissance de l'aster étaient soit érodés (e.g., *Pointe des véliplanchistes*), soit perturbés par des dépôts de zostère (e.g., *Pointe aux canots*) ou soit complètement inondés (e.g., *Dune de l'ouest*). Ceci pourrait avoir eu pour effet de diminuer l'effectif des populations à des valeurs plus basses que la moyenne.

Les VTT semblent avoir un impact positif sur la croissance démographique de deux populations (*Baie de Grosse-Île* et *Baie Clarke*). Ceci peut être expliqué de deux façons. Premièrement, le passage récurrent des VTT peut créer le gradient de perturbation physique nécessaire à limiter la croissance des compétiteurs de l'aster du Saint-Laurent en permettant la croissance de celle-ci. La dynamique retrouvée le long des lagunes est conservée et les événements d'inondation sont remplacés par le passage d'un VTT. Deuxièmement, les VTT circulant sur de longues distances et créant un mouvement de l'air par leur passage peuvent faciliter la dissémination des akhènes d'aster qui pourra s'établir facilement sur le sol dénudé laissé par le passage des véhicules.

En résumé, les populations *Cap de l'hôpital*, *Barachois*, *Havre aux Basques*, *Étang des caps*, *Baie de Grosse-Île*, *Baie Clarke* et *Bassin aux Huîtres (club vacance)* sont stables ou en croissance. Les populations *Barachois (Chemin Poirier)*, *Pointe des véliplanchistes*, *Pointe aux canots*, *Dune de l'ouest* et *Bassin aux Huîtres (est et ouest)* semblent décliner. Enfin, les populations *Étang du Nord*, *Pointe Old-Harry*, *Bassin aux Huîtres (centre)* semblent éteintes. Par contre, puisqu'il demeure difficile de départager entre une tendance continue au déclin et une dynamique variable selon les conditions annuelles, un suivi des populations à long terme demeure l'outil à privilégier.

Élaboration d'un protocole de suivi simple

Puisque plusieurs sites étaient fortement perturbés lors de la visite de 2004 et que plusieurs populations semblaient être caractérisées par des effectifs plus faibles que ceux observés dans d'autres études (e.g., populations de *Dune de l'ouest* ou *Pointe des véliplanchistes*), le suivi devra inclure une visite annuelle de toutes les populations. La revisite de l'ensemble des populations permettra de continuellement mettre à jour les données d'effectif, de localisation et de superficie des populations. Une revisite de ces populations pourra éventuellement permettre l'établissement de nouveaux transects permanents sur des populations importantes mais où il n'y avait pas de sites favorables en 2004. De plus, une attention particulière pourrait être portée sur les populations de *Baie de Grosse-Île* et de *Baie Clarke* qui subsistent et dont l'effectif semble même augmenter grâce à des perturbations d'origine anthropique liées au passage récurrent de VTT. Aucun transect permanent n'a été établi sur ces sites puisque les piquets auraient certainement nuit au passage des VTT et auraient été immédiatement retirés. Cependant, cette dynamique liée à la perturbation d'origine anthropique est intéressante et mérite que l'on s'y attarde à l'avenir.

Enfin, on peut s'attendre à ce que la ligne du rivage soit dépendante de la quantité de précipitations reçues. Par conséquent, il est fort possible que cette ligne varie et qu'il soit nécessaire de réajuster l'emplacement des transects au cours des prochaines années afin de couvrir adéquatement l'habitat de l'aster. Une façon de le faire est de visualiser chaque transect permanent comme deux lignes parallèles séparées par 1 m et d'une longueur indéfinie dont le premier quadrat (de 1 m × 0.5 m) est à proximité de la ligne du rivage et le dernier est situé 2.5 m plus loin pour donner un transect d'échantillonnage d'une longueur totale constante de 3 m. Si, au cours des prochaines années, il est noté que la ligne du rivage se déplace, les transects installés actuellement serviront de bornes indiquant les deux lignes parallèles; il ne suffira que

de tirer des lignes continues jusqu'à la ligne du rivage pour y installer le premier quadrat. Si une telle démarche doit être utilisée, il faudrait inclure dans le suivi la mesure de la distance de déplacement du transect par rapport au transect permanent original.

Description de la situation actuelle aux populations sélectionnées pour le suivi

Les résultats ont montré que les trois populations choisies pour le suivi à long terme présentent des différences significatives pour toutes les variables incluses dans le suivi. La population *Étang des caps* présente la plus forte densité et les individus de cette population couvrent un plus grand pourcentage de sol. Ces résultats soutiennent les estimés de l'effectif où *Étang des caps* était considérée comme la seule population de classe 6. Ceci peut être dû à une faible compétition interspécifique, puisque les résultats de l'analyse ont montré qu'il s'agit du site où le pourcentage de l'ensemble de la végétation et la richesse spécifique sont les plus faibles. Ceci indique donc une différence au niveau de la dynamique de cette population par rapport aux deux autres populations. Cette dynamique favorise la croissance de l'aster par rapport aux autres espèces.

Les individus de la population *Havre aux Basques* ont atteint en 2004 une taille plus haute et possèdent davantage de capitules alors que les individus de la population *Barachois* étaient, au contraire, les plus petits et les moins ramifiés. La densité de la population du *Barachois* est deux fois plus élevée que celle observée au *Havre aux Basques*. Il est intéressant de constater que toutes les autres variables mesurées à ces deux sites ne présentent pas de différences significatives. Ces deux populations semblent donc utiliser deux stratégies morphologiques distinctes. La population du *Barachois* double la quantité de tiges mais réduit la taille et le nombre de capitules de celles-ci, alors que la population du *Havre aux Basques*, moins dense est composée d'individus plus hauts et ramifiés. Ces deux stratégies permettent d'obtenir le même pourcentage de couverture par l'aster. Il semble que la compétition interspécifique ne soit pas reliée à l'utilisation de l'une ou l'autre de ces stratégies puisque les deux populations sont situées sur des sites ayant une même richesse spécifique et un même pourcentage de couverture de végétation. L'utilisation de stratégies distinctes doit donc être reliée à une variable qui n'a pas été mesurée dans le suivi telle que la salinité du substrat qui inhibe la germination (Houle et al. 2001) ou une période de sécheresse en début de saison de croissance qui retarde l'établissement des plantules (Houle et Belleau 2000).

Il appert que les trois populations possèdent des différences qui renseignent sur l'importance de la densité, la morphologie et l'habitat. Par conséquent, il est fortement suggéré de conserver ces trois populations et ces six variables dans le suivi à long terme afin de vérifier dans quelle mesure ces populations conservent les mêmes caractéristiques au cours des années subséquentes ou si la dynamique est sujette à changer (e.g., en fonction de la quantité de précipitations). Aussi, tel que mentionné plus haut, l'inclusion de nouvelles populations est recommandée, particulièrement celles dont les effectifs varient entre les études (e.g., *Dune de l'ouest*, *Pointe des véliplanchistes*, *Pointe aux canots*).

Pour quatre des six variables, il existe des différences significatives entre les cinq transects de chaque population. Ceci suggère que les transects ne sont pas des réplicats et qu'ils doivent plutôt être considérés comme différents micro-habitats. Par conséquent, il est important de conserver les quinze transects dans le suivi à long terme. Retirer un transect constituerait une perte significative d'information. Les données recueillies au cours des prochaines années du suivi, permettront en plus de comparer la progression d'un même transect au cours du temps. Ceci permettra de voir comment chaque micro-habitat se transforme.

Même si les transects ne sont pas de véritables réplicats, il est possible de discerner des relations significatives des différentes variables en fonction de la distance par rapport à la ligne du rivage pour deux populations. Le plan d'échantillonnage de transects organisés perpendiculairement à la ligne de rivage sur une distance de 3 m permet de couvrir le gradient de perturbation / compétition attendu sur deux sites. En effet, aux populations de HAB et EDC, le nombre de tiges et le pourcentage de couverture par l'aster de même que les valeurs associées aux variables morphologiques (la hauteur des tiges et le nombre de capitules par individu) sont faibles près de la ligne du rivage où le stress lié à la salinité (Houle et al. 2001; Reynolds et al. 2001) et les perturbations (Reynolds et Houle 2002) empêchent la croissance de l'aster. En s'éloignant du rivage, les conditions du milieu favorisent la croissance de l'aster mais demeurent trop restrictives pour la croissance d'espèces compétitrices. Le mode de la distribution se situe dans cette bande intermédiaire. À une distance plus éloignée de la rive, les conditions deviennent favorables pour des espèces plus compétitrices qui limitent la croissance de l'aster (Brumbt 2001; Houle et Valéry 2003). Ce gradient est confirmé par le pourcentage de couverture par l'ensemble de la végétation qui augmente de façon linéaire à partir de la ligne du rivage. La richesse spécifique suit la distribution quadratique à la population *Havre aux Basques*. Il semble que cette relation soit un artéfact de la relation entre diversité et productivité fréquemment observée (Grime 1973; Rosenzweig 1992; Huston et deAngelis 1994; de Lafontaine 2004). En effet, le maximum de richesse est observé à la distance correspondant à des valeurs intermédiaires de pourcentage de couverture de l'ensemble de la végétation.

Par contre, à la population *Barachois*, le plan d'échantillonnage ne permet pas de déceler le gradient de perturbation / compétition attendu. Le site est particulier et les transects T4 et T5 ont été positionnés un

peu en retrait par rapport à la ligne du rivage puisque la plupart des individus ne sont pas situés dans l'habitat typique de la bande de 3 m après la ligne de rivage. Il est possible de redéfinir l'emplacement de ces transects afin qu'ils correspondent plus adéquatement au gradient typique. Il se peut que cette démarche uniformise les transects à ce site créant ainsi de véritables réplicats. Cependant, tant que ces transects seront peuplés d'aster, il est plutôt conseillé de les conserver tels qu'ils sont présentement en tenant compte de cette particularité dans le suivi à long terme.

Conclusions

Cette étude définit 18 populations. Les 7 populations *Cap de l'hôpital*, *Barachois*, *Havre aux Basques*, *Étang des caps*, *Baie de Grosse-Île*, *Baie Clarke* et *Bassin aux Huîtres (club vacance)* sont stables ou en croissance. Les 6 populations *Barachois (Chemin Poirier)*, *Pointe des véliplanchistes*, *Pointe aux canots*, *Dune de l'ouest* et *Bassin aux Huîtres (est et ouest)* semblent décliner. Enfin, les 3 populations *Étang du Nord*, *Pointe Old-Harry*, *Bassin aux Huîtres (centre)* semblent éteintes ou très près de l'extinction. La population *Pointe de l'est* n'a pas été revisitée et cette étude présente le premier estimé de la population *Baie du portage*. À partir des études qui ont été réalisées en utilisant différentes approches, il est difficile de départager entre de réelles tendances au déclin et une dynamique en fonction des conditions changeantes du milieu. L'utilisation d'un suivi à long terme appliquant un protocole uniforme permettra de déterminer la progression des différentes populations.

Un protocole a été élaboré et le plan d'échantillonnage a été installé à trois populations : *Barachois*, *Havre aux Basques* et *Étang des caps*. Il est conseillé d'installer le plan d'échantillonnage sur d'autres sites importants où les effectifs semblent en déclin mais sur lesquels il était impossible d'établir des transects en 2004 (*Dune de l'ouest*, *Pointe aux canots*, *Pointe des véliplanchistes*). Il serait également intéressant d'étudier la dynamique des populations d'aster perturbées par le passage récurrent des VTT (*Baie de Grosse-Île* et *Baie Clarke*). Enfin, il est recommandé d'effectuer une visite annuelle des 18 populations.

Au sein des trois populations sélectionnées pour le suivi, les résultats obtenus en 2004 montrent des différences significatives pour toutes les variables considérées. Aux trois sites, les transects présentent des différences entre eux et ne peuvent donc pas être considérés comme des réplicats. À la lumière de ces informations, il est recommandé de conserver les trois populations pour le suivi à long terme et de conserver les cinq transects tels qu'ils se présentent actuellement. Le plan d'échantillonnage permet de déceler le gradient de perturbation / compétition attendu sauf à la population plus particulière du *Barachois*. Ceci indique que pour les populations de *Havre aux Basques* et *Étang des caps*, ce plan d'échantillonnage permet de tenir compte de la variation par rapport à la ligne du rivage et devrait être conservé comme tel. Cependant, les transects 4 et 5 de la population du *Barachois* ont été déplacés à cause de contraintes particulières associées à ce site. Ces transects devraient être laissés ainsi et l'analyse devra en tenir compte.

Remerciements

Le soutien financier a été fourni par le ministère du développement durable, environment et parcs du Québec et Environnement Canada. Les données ont été fournies par le ministère du développement durable, environment et parcs du Québec .

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Received 24 January 2005
Accepted 13 October 2005

Tree Recruitment Limitation by Introduced Snowshoe Hares, *Lepus americanus*, on Kent Island, New Brunswick

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Peterson, Trevor, Akane Uesugi, and John Lichter. 2005. Tree recruitment limitation by introduced Snowshoe Hares, *Lepus americanus,* on Kent Island, New Brunswick. Canadian Field-Naturalist 119(4): 569-572.

Species introductions often have negative consequences for native plant and animal communities of islands. Herbivores introduced to islands lacking predators can attain high population densities and alter native plant communities by selective consumption of palatable plants. We examined the legacy of the 1959 introduction of Snowshoe Hares (*Lepus americanus*) to Kent Island, New Brunswick, by reconstructing a history of tree recruitment on Kent Island and on nearby Outer Wood Island, which lacks Snowshoe Hares. Tree-ring records show pronounced recruitment peaks associated with farm abandonment in the 1930s for Kent Island and in the 1950s for Outer Wood Island. Following the introduction of Snowshoe Hares to Kent Island, tree recruitment plummeted and has remained low ever since. In contrast, trees continued to establish throughout the latter 20th century on Outer Wood Island. The high rates of seedling mortality on Kent Island associated with Snowshoe Hare browsing coupled with high rates of canopy tree mortality threaten to degrade severely the forest of this important seabird nesting sanctuary.

Key Words: Snowshoe Hare, *Lepus americanus*, invasive species, tree recruitment limitation, Kent Island seabird sanctuary, New Brunswick.

Introduced herbivores often cause great damage to island ecosystems and potentially result in plant species extinction (Van Vuren and Coblentz 1987; Moran 1996; Coblentz 1990). The absence of significant predators allows introduced herbivores to reach high population densities and exert intense grazing pressure on poorly defended plants (Krebs et al. 2002; Donlan et al. 2002). Because woody plants are most vulnerable to browsing during their early stages of development and growth (Clark et al. 1999; Liang and Seagle 2002), intense browsing may limit tree regeneration and allow less palatable species to proliferate (Rossow et al. 1997; Heinen and Currey 2000). Shifts in plant species dominance resulting from intense herbivory have been demonstrated in tropical, temperate, and boreal island ecosystems and indicate the community-level impacts of herbivore introductions or predator removal from islands (McLaren and Peterson 1994; Chouinard and Filion 2001; Terborgh et al. 2001).

In 1959, Snowshoe Hares (*Lepus americanus*) colonized Kent Island, an 80-hectare island in the Bay of Fundy, New Brunswick, following intentional introduction to Hay Island, a nearby island connected to Kent Island at low tide (C. Huntington, personal communication). Subsequently, estimates of the hare population in various years have ranged between 50 and 500 individuals based on mark-recapture techniques (N. Wheelwright, Bowdoin College; personal communication). Snowshoe Hares are generalist herbivores that feed on a variety of grasses and shrubs during the summer, but on tree bark, foliage, and twigs during the winter (de Vos 1964). Diet selection studies have demonstrated that hares preferentially browse deciduous species, but may rely on conifers during winter or during periods of high population density if preferred forage is not available (Aldous and Aldous 1944; de Vos 1964; Parker 1984). Snowshoe Hares often avoid White Spruce (*Picea glauca*) when other browse is available, presumably because of high levels of camphor in the foliage (Sinclair et al. 1988; Rangen et al. 1994; Heinen and Currey 2000). The concentration of secondary compounds in vegetation may also influence diet selection (Fox and Bryant 1984; Rousi 1997; Rodgers and Sinclair 1997). Paper Birch (*Betula papyrifera*) saplings, for example, can effectively deter Snowshoe Hare browsing with high concentrations of secondary compounds (Bryant 1981).

Although Snowshoe Hare browsing of trees is generally limited to heights less than 1 m, hares are important herbivores in boreal forests, and considerable damage to seedlings and saplings in forest plantations has been attributed to hares (Aldous and Aldous 1944; Holl and Quiros-Nietzen 1999; Rao et al. 2003). Based on Kent Island's high population of Snowshoe Hares and on observations of intense browsing of tree seedlings, we hypothesized that browsing by hares effectively halted tree recruitment since their introduction in 1959. To document the impacts of hare browsing on Kent Island, we reconstructed a tree recruitment history based on tree-ring records for Kent Island and for nearby Outer Wood Island, which lacks Snowshoe Hares. We also compared current tree recruitment rates on the two islands by estimating seedling and sapling densities in randomly located plots.

Study Area

Kent Island is at the southern end of the Grand Manan archipelago in the Bay of Fundy, New Brunswick (44°35'N, 66°46'W). The island is an important nesting area for Leach's Storm Petrel (*Oceanodroma leucorhoa*) and Savannah Sparrow (*Passerculus sandwichensis*). Since 1935, Bowdoin College of Brunswick, Maine, has operated a biological station on Kent Island. In 1959, Snowshoe Hares were intentionally introduced to nearby Hay Island, and soon thereafter crossed the tidally exposed land bridge to Kent Island. Hare populations have persisted on both islands since that time. Muskrats (*Ondatra zibethicus*) were introduced earlier in 1941 (Huntington 1956). The forest community contains Balsam Fir (*Abies balsamea*), White Spruce, Red Spruce (*Picea rubens*), Yellow Birch (*Betula allegheniensis*), Heart-leaved Birch (*Betula cordifolia*), and Mountain Ash (*Sorbus americanus*). A mixed forest dominated by White Spruce and Balsam Fir covers approximately two-thirds of the northern half of the island, whereas grassland covers the southern half of the island. In the early 20th century, much of the grassland was either cultivated or used for hayfield and pasture (Gleason 1937). Today seedlings and saplings of any tree species are rare on Kent Island. Those that are found show a pronounced browse line up to 60 cm in height. Canopy trees are suffering high rates of mortality for unknown reasons, and the gaps formed by tree death and windthrow are rapidly colonized by Red Raspberry (*Rubus idaeus*) and Wood Fern (*Dryopteris spinulosa*) rather than trees.

Outer Wood Island (44°37'N, 66°49'W) is approximately 6 km northwest of Kent Island. Forest covers its central area, which is surrounded by grasslands similar to Kent Island. White Spruce and Red Spruce are the dominant canopy species with Balsam Fir, Yellow Birch, and Mountain Ash important locally. Outer Wood Island lacks Snowshoe Hares, but, like Kent Island, has a large introduced Muskrat population. Outer Wood Island was used for sheep pasture throughout the early and middle 20th century (Ingersoll 1991).

Methods

In March 2002, an attempt to eradicate the Snowshoe Hare population on Kent Island was initiated, which resulted in a reasonably accurate population estimate. Eradication efforts have continued up to the present. Prior to the attempted hare eradication, we counted hare pellets in 132 plots (1 m × 1 m) randomly located within forests on Kent Island to document hare distribution on the island, as described by Krebs et al. (2001).

To describe the composition of the forests, we examined trees occurring along the length of nine randomly located 2 m × 50 m transects on each island. Canopy trees were identified to species and their diameter-at-breast-height (DBH) was recorded. To develop tree-recruitment histories, we collected increment cores from White Spruce, Red Spruce, and Balsam Fir trees in nine randomly chosen circular plots on each island. Within each plot, the ten trees nearest the center and greater than 5-cm DBH were cored at a height ranging between 30 and 50 cm from the ground. The species identity and DBH were recorded for all cored trees. We also took advantage of numerous treefalls that occurred during the winter of 2000-2001 by collecting basal discs from 33 trees. The discs and cores were sanded smooth, and the rings were counted using a binocular Leica dissecting microscope and a Velmex tree-ring measuring system. To account for early growth of the trees, we added five years to the tree-age estimates of basal discs and ten years to the estimates of increment cores (DesRochers and Gagnon 1997; Parent et al. 2000).

On both islands, established seedlings and saplings were quantified in three 78.5-m^2 (i.e., 5-m radius) sample plots, located 25 m apart along each 50-m transect. Seedlings were defined as any stem less than 1 m in height and saplings were defined as stems greater than 1 m in height and having a DBH less than 5 cm. Height measurements and extent-of-browsing estimates were recorded on isolated White Spruce seedlings on Kent Island and Outer Wood Island.

Results

The density of Snowshoe Hare pellets on Kent Island was 47.1 ($\pm$ 6.2)/m^2 and ranged between 6 and 110 pellets/m^2. Pellet densities were not significantly correlated with seedling abundances. No pellets were found on Outer Wood Island. After one month of hunting in early 2002, 275 Snowshoe Hares had been killed on Kent Island, indicating a minimum density of 3.43 hares per hectare. The hare population was not eliminated during this period of hunting, and the population has subsequently rebounded, although not to its maximum level. Eradication efforts are scheduled to continue in winter 2005-2006.

The recruitment histories of canopy trees of the two islands show patterns of reforestation following farm abandonment and cessation of livestock grazing in the mid-20th century (Ingersoll 1991). Consistent with the timing of land-use change, peak tree recruitment occurred during the 1930s on Kent Island and during the 1950s on Outer Wood Island (Figure 1). On Kent Island, tree recruitment remained high through the 1940s but declined precipitously in the 1950s, whereas tree recruitment on Outer Wood Island was relatively high throughout the 1960s and 1970s, two decades after its peak (Figure 1).

The abundances of saplings and established seedlings (i.e., > 2 yrs old) reveal the disparity in recent tree recruitment on the two islands. Sapling abundance of all tree species was much greater on Outer Wood Island than on Kent Island (OWI = 29.4 $\pm$ 13.3; KI = 0.1 $\pm$ 0.1; df = 43; t = 2.71; P = 0.01) (Figure 2). The abundance of established seedlings was similarly

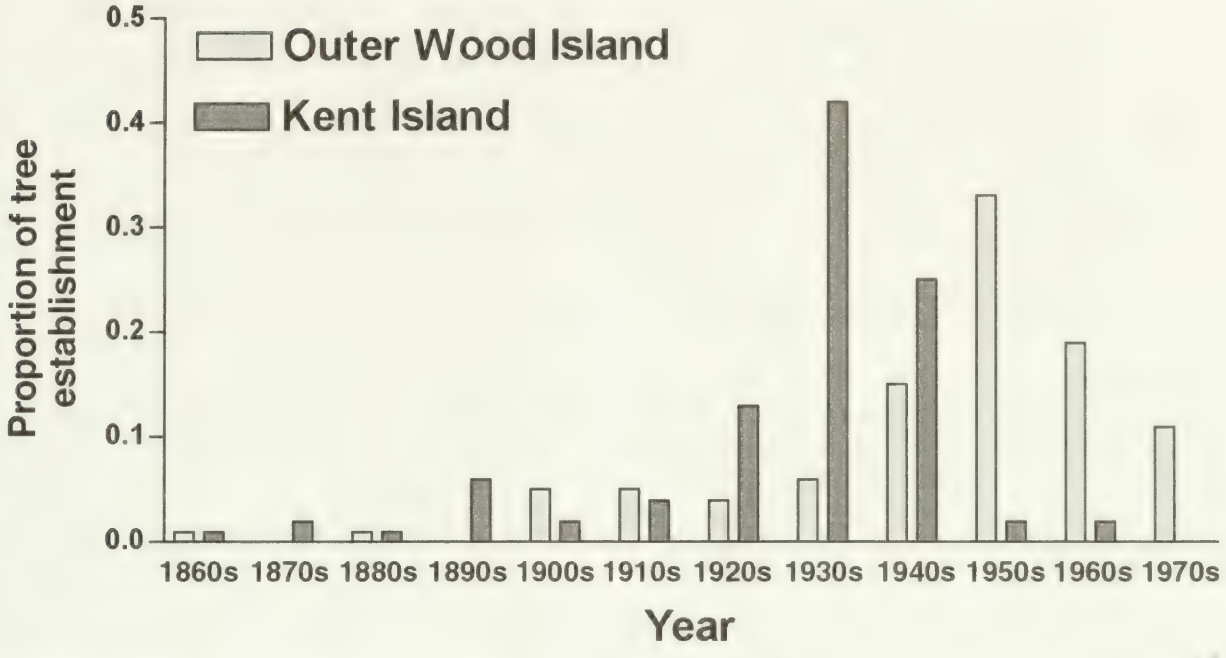

FIGURE 1. Tree recruitment history for Kent Island and Outer Wood Island, New Brunswick derived from tree-ring records. Data given as the proportion of the total number of canopy trees cored for each decade between 1860 and 1980. Snowshoe Hares were introduced to Kent Island in 1959.

much greater on Outer Wood Island than on Kent Island (OWI = 14.1 + 3.5; KI = 0.3 + 0.2; df = 43; t = 3.17; $P = 0.003$). All of the 58 spruce seedlings and saplings examined on Kent Island showed visible signs of browsing. Of these 58 trees, 40 were less than one meter in height, and 18 between 1 and 2 m tall. Of the 40 less than 1 m in height, 24 were missing their apical meristem, whereas of the 18 ranging between 1 and 2 m in height, only one had its apical meristem browsed. On Outer Wood Island, apical stems were present on all 60 of the seedlings sampled, and little or no evidence of browsing was present.

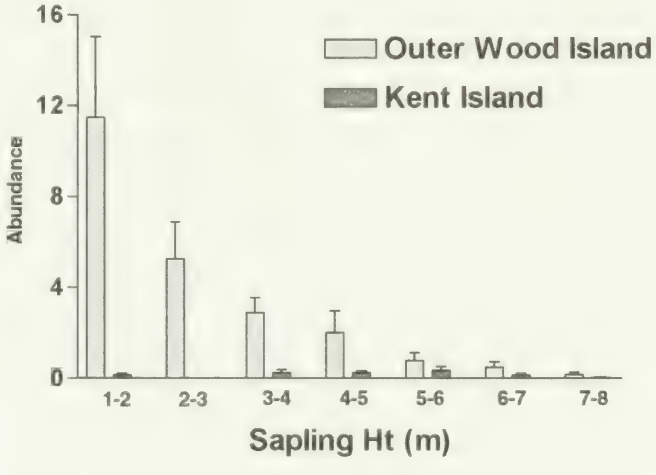

FIGURE 2. Tree sapling abundance for Kent Island and Outer Wood Island, New Brunswick, given for height classes.

Discussion

The history of tree recruitment on Kent Island and Outer Wood Island demonstrates the long-term, negative effects of intense Snowshoe Hare browsing on tree recruitment in an island ecosystem lacking mammalian predators. The precipitous decline of tree recruitment on Kent Island during the 1950s suggests that the Snowshoe Hare population increased rapidly and that few established tree seedlings survived the onset of hare browsing. While we have no sequential estimates of the hare population density, the lack of saplings and established seedlings suggests that hares were numerous enough to limit tree recruitment severely throughout the past forty-five years. Sustained browsing pressure can cause a shift toward less palatable species (McLaren and Peterson 1994; Heinen and Currey 2000; Terborgh et al. 2001). Because all tree species on Kent Island are palatable to Snowshoe Hares, a shift to less palatable species would result in loss of forest. Currently as canopy trees die, Wood Fern and Red Raspberry replace them. A dense cover of Wood Ferns probably also limits tree recruitment as Wood Ferns have been shown to limit the photosynthetic capabilities of coniferous seedlings (Starostina 1988).

This study contributes to a growing body of research documenting pronounced ecosystem-level consequences of herbivore introductions to islands (e.g., Van Vuren and Coblentz 1987; Donlan et al. 2003). Because Snowshoe Hares are the only mammalian herbivores that browse trees on Kent Island, they are responsible for all of the browsing damage since their introduction. If the current hare eradication efforts are not successful, it is likely that this forest will become severely degraded in the future as the canopy trees reach senescence. This outcome may negatively affect the suitability of the island as nesting habitat for Leach's Storm Petrels,

whose nest sites are currently concentrated in the forested portions of the island. This would be unfortunate, because Kent Island provides vital and well-documented nesting habitat for Leach's Storm Petrel (Gross 1935; Griffin 1940; Huntington 1956, 1959). Successful eradication of Snowshoe Hares from Kent Island would provide a valuable opportunity to document whether removal of the dominant herbivore will allow the forest community of the island to recover from nearly half a century of suppressed tree recruitment.

Acknowledgments

We sincerely thank Nat Wheelwright, Barry Logan, and Chuck Huntington for thoughtful comments on this manuscript, and Sarah Rodgers, Jaret Reblin, and Peter Hill for help in the field. This is contribution number 154 from the Kent Island Scientific Station.

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Received 11 January 2005
Accepted 26 September 2005

Travel Rates of Wolves, *Canis lupus*, in Relation to Ungulate Kill Sites in Westcentral Alberta

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Kuzyk, Gerald W., Christoph Rohner, and Fiona K. A. Schmiegelow. 2005. Travel rates of Wolves, *Canis lupus*, in relation to ungulate kill sites in westcentral Alberta. Canadian Field-Naturalist 119(4): 573-577.

Recent advancements in Global Positioning Systems (GPS) radiocollar technology permit analysis of fine-scale animal movements. We used concurrent aerial and GPS monitoring to determine winter travel rates of Wolves (*Canis lupus*) in relation to ungulate kill sites in managed forest landscapes in westcentral Alberta. Wolves preyed predominately on Moose (*Alces alces*) and travelled 4.2 times less when near ungulate kill sites than when away from them. As Wolves are thought to be an important factor in Woodland Caribou (*Rangifer tarandus caribou*) declines, information is needed to assess predation risk to Caribou from Wolves under a variety of landscape conditions. If Wolves have restricted movements near Moose kill sites, this may lead to decreased encounter rates with Caribou in systems where Moose are abundant. Deer (*Odocoileus* spp.) are probably an important component of this Wolf-prey system but little is currently known about this relationship. Projecting long-term implications of ongoing development activities requires a more detailed understanding of the responses of all species to landscape change.

Key Words: Moose, *Alces alces*, Wolf, *Canis lupus*, predation risk, Woodland Caribou, *Rangifer tarandus caribou*, GPS data, Alberta.

Wolves (*Canis lupus*) travel extensively to locate prey (Mech 1970). For example, when hunting Moose (*Alces alces*), Wolves may travel 30-50 kilometres per day (Mech 1966; Peterson 1977; Mech et al. 1998). Woodland Caribou (*Rangifer tarandus caribou*) are classed as threatened in Alberta (Edmonds 1998; Dzus 2001) and Wolf predation is thought to be a major contributor to Caribou declines (Bergerud 1974; Edmonds 1988; Hayes et al. 2003). It is hypothesized that Woodland Caribou spatially separate themselves from Moose to avoid predation by Wolves (Bergerud and Elliot 1986; Seip 1992). Wolves may alter their use of habitats in response to industrial development such as forest harvesting (Kuzyk et al. 2004) and human infrastructure such as roads and trails can enhance Wolf movements (Formozov 1946; Thurber et al. 1994; Ciucci et al. 2003). James (1999) reported that Wolves in winter travelled 2.8 times faster on a linear corridor than in the forest. Such enhanced mobility has implications for search efficiency and encounter rates of Wolves with prey species. Increased information on Wolf-prey systems is essential for future Caribou conservation decisions (Hayes et al. 2003). Understanding Wolf travel rates in relation to ungulate kill sites offers one method of assessing predation risk to other prey species.

When Wolves kill large prey such as Moose, they usually spend two to four days near the carcass (Peterson 1977; Ballard et al. 1987; Mech et al. 1998; Hayes et al. 2000) whereas White-tailed Deer (*Odocoileus virginianus*) carcasses are generally handled in less than one day (Fuller 1989). After feeding on an ungulate carcass, Wolves may travel several kilometres to rest in open sunny areas, where digestion may be optimized (Mech 1970). During one study, Wolves were found near Moose kills in 21 of 31 days of continuous monitoring (Mech 1966), but fine scale movements near the carcasses were not recorded.

Observational studies of Wolves provide useful insight into Wolf hunting behaviour (Carbyn and Trottier 1988; Mech 1997) but there is little quantitative information on Wolf movements near kill sites, due to the technical difficulties of collecting such information (Mech 1995). Wolves have traditionally been studied using daily aircraft flights to relocate radiocollared Wolf packs, but this technique is limited by daylight and favourable weather (Mech 1995).

The objective of this study was to combine Global Positioning Systems (GPS) radio-collar technology with concurrent aerial observations to provide detailed information on Wolf travel rates in relation to ungulate kill sites. Wolves feeding on Moose are predicted to restrict movements when near carcasses (Mech 1966; Mech 1970) which should, theoretically, lessen predation risk to Caribou in systems where moose are abundant. Wolf packs feeding on deer should spend minimal time at kill sites (Fuller 1989), and more time travelling, which could result in increased predation risk to Caribou through random encounters.

Study Area

The study area is located in the foothills of west-central Alberta, near the town of Grande Cache (54°N 119°W). The area is classed into subalpine and boreal natural subregions (Beckingham and Archibald 1996), and contains several main rivers and a dendritic pattern of creeks; lakes are scarce. Elevations range from 1300-1800 metres, and the climate is subarctic, with short wet summers and long cold winters. Temperatures aver-

age 16°C in July and -13.5°C in December (Beckingham and Archibald 1996). The forests are primarily Lodgepole Pine (*Pinus contorta*) and some White Spruce (*Picea glauca*). The wetland complexes support mostly Black Spruce (*Picea mariana*) and some Tamarack (*Larix laricina*). Some south facing slopes support Trembling Aspen (*Populus tremuloides*) and willow (*Salix* sp.).

This area supports a high diversity of large mammals: Woodland Caribou, Moose, Elk (*Cervus elaphus*), White-tailed Deer, Mule Deer (*Odocoileus heminous*), Bighorn Sheep (*Ovis canadensis*), Mountain Goats (*Oreamnos americanus*) and wild Horses (*Equus cabalus*). Wolves, Coyotes (*C. latrans*), Grizzly Bears (*Ursus arctos*), Black Bears (*Ursus americanus*) and Cougars (*Felis concolor*) also exist throughout the study area.

Major land use activities include forest harvesting, oil and gas exploration and development, coal mining, commercial trapping, and public uses such as hunting, fishing, hiking, horse packing and camping. Access is primarily on roads created for resource extraction, pipelines and seismic lines. Further descriptions of the study area can be found in Smith et al. (2000).

Wolf captures and radio-tracking

In January 2000, three Wolves from different packs (Simonette, Cutbank and Prairie Creek) were captured and immobilized by helicopter darting (Ballard et al. 1991) or netgunning (Kuzyk 2002) and instrumented with GPS radiocollars (Lotek Engineering Sytems, Newmarket, Ontario). All Wolf handling was approved by the University of Alberta's Faculty of Agriculture, Forestry and Home Economics Animal Care Policy (Number 96-99D), subject to the protocols of the Canadian Council of Animal Welfare. GPS collars were programmed to take one location per hour.

During a short period of intensive sampling, from 2-15 March 2000, these radiocollared Wolves and their associated pack members were followed by radiotracking from an airplane (Mech 1974). Wolves were relocated twice daily in hopes of detecting Wolf-killed deer (Fuller 1989). When a Wolf pack was located, the Wolves were counted and the area searched for ungulate carcasses. If an ungulate kill or most Wolf pack members were not immediately found, Wolf trails were backtracked until an ungulate carcass was found (Hayes et al. 2000).

Wolf kill sites

An ungulate kill was assumed to be caused by Wolves if there was evidence of bloodstained snow, a disarticulated carcass and Wolf trails indicating a successful chase (Hayes et al. 2000). Wolves were assumed to be scavenging if the carcass was on its sternum (Ballard et al. 1987) or human sign indicated the ungulate had been shot or road-killed. A GPS location was taken from an aircraft when directly over the kill site, with an estimated error of 73-128 metres (Carrel et al. 1997). Kill sites were visited twice daily until the Wolves abandoned the carcass. Wolves were classified as being near a kill when all or most members of the pack were seen within one kilometre of the new kill site.

Dead Moose were classified from the air as adult or calf (Peterson 1977). The amount of meat removed from the carcass was estimated (Carbyn 1983) and the number and behaviour of Wolves were recorded. All Wolf-killed ungulates for which species, sex and age (adult-calf) could not be confirmed from an airplane, and all others that were easily accessible with a helicopter, were later ground-inspected.

Data analysis

GPS location data were differentially corrected using N4Win Version 2.40, which reduced location error to 4-5 metres (Rempel and Rodgers 1997). Median travel distances in metres per one-hour interval (m/hr) were classified as kill site or non-kill site by calibrating the GPS data with field observation data. This was achieved by establishing a median time between each aerial observation in which Wolves were either near or away from an ungulate kill site. For example, if a Wolf pack was observed travelling at 1800 hr in the evening, and then relocated near a recent ungulate kill at 0800 hr the following morning (a time of 14 hours), the travel distances in the first seven-hour period were placed in the non-kill site category. Those distances in the remaining seven hour period were placed in the kill site category. While both calculation of straight-line distances between remotely-collected locations and proportional assignment of time intervals to behaviour categories can introduce errors in absolute representation of patterns, associated errors were consistent across all data collected. Further, because we were interested in relative patterns, rather than absolute measures, we do not feel these limitations unduly compromise our results.

All data were tested for normality before analysis and non-parametric procedures were used. All analyses were completed using SYSTAT (Version 8.0, SPSS Inc. 1998). To determine if travel distances differed when Wolves were near or away from ungulate kill sites, the GPS locations from the collared Wolves were pooled and classified into two categories: at or away from an ungulate kill site. A Mann-Whitney *U*-test was used to test for differences in travel distance between these two categories. To examine variation in travel rates among wolf packs, location data for each pack were similarly divided into two categories (kill site/non-kill site), and analysed separately using Mann-Whitney *U*-tests.

Results

The three Wolf packs were located at seven ungulate kill sites from 2-15 March 2000 (Table 1). The Simonette Wolf pack made multiple kills at two sites: a cow and calf Moose were killed within 500 metres of each other on or near the same day, and the scattered remains of two deer kills were found within 100 metres of each

TABLE 1. Ungulate kill sites of three Wolf packs during 2-15 March 2000 in west-central Alberta.

Wolf Pack and Size (n)	Adult Moose	Calf Moose	Adult Elk	Deer
Cutbank (n = 8)	1	1	0	0
Prairie Creek (n = 5)	0	0	1	0
Simonette (n = 11)	3*	0	0	1**
Totals	4	1	1	1

* includes one multiple kill of 1 cow and 1 calf Moose which is considered 1 kill
** includes one multiple kill of 2 deer which is considered 1 kill

TABLE 2. Wolf travel distances (m/hr) at and away from seven ungulate kill sites as determined by one-hour GPS locations from three Wolves in separate packs during 2-15 March 2000 in west-central Alberta.

	All Travel (m/hr)	Travel at Kill (m/hr)	Travel Away from Kill (m/hr)
Number of cases	553	288	265
Minimum	0.2	0.2	0
Maximum	6100	2044	6100
Standard Deviation	749	326	963
Median*	80	45	190

*(Mann-Whitney U test $P \leq 0.001$)

other (Table 1). To be conservative, multiple kills were pooled for analysis.

Wolves travelled a median distance of 80 m/hr during 14 consecutive days of monitoring (Table 2). They moved a median distance of 45 m/hr when near ungulate kill sites, which differed significantly from a median distance of 190 m/hr per hour when they were not near kill sites ($U = 26\,362$, $P \leq 0.001$).

Patterns in travel distance varied among Wolf packs. The Cutbank Wolf pack, which was only observed on Moose kills during the monitoring period, showed a highly significant difference ($U = 1667$, $P \leq 0.001$) in travel distances when at or away from kill sites. The Simonette pack, which was found near both Moose and deer kills, showed a marginally significant difference ($U = 2740$, $P = 0.067$) between travel distances at and away from kill sites. During aerial monitoring, only one Elk kill was recorded for the Prairie Creek pack and no difference ($U = 2702$, $P = 0.601$) in travel distances related to kill sites was detected (Table 3).

Discussion

In this study, GPS radiocollar technology allowed Wolf travel rates to be recorded on a continuous (hourly) basis, irrespective of daylight and weather, and accounted for associated feeding, resting and other social behaviours. Further, by combining GPS radio-collar technology with traditional methods used to study wolf kill rates (Mech 1974), a more comprehensive representation of wolf travel rates was established. Results from this approach found a clear difference in Wolf travel rates related to ungulate kill sites, which is consistent with both anecdotal information and other research (Mech 1966; Peterson 1977; Hayes et al. 2000).

We found that Wolves travelled a median distance of 0.08 km/hr, which is substantially lower than that reported for Wolves travelling in the forest during winter (1.6-6.1 km/hr) (Musiani et al. 1998), on iced surfaces (8 km/hr) (Mech 1966), and on tundra during summer (8.7 km/hr) (Mech 1994). This difference could be largely due to the advantages of continuous (hourly) GPS monitoring in this study. While the data-collecting period seldom lasted more than a few hours in other studies, due to the requirement for maintenance of visual or auditory contact with the Wolves (Musani et al. 1998; Mech 1994), GPS technology provides for continuous data collection. As such, it provides information on movement patterns of Wolves that includes time spent in a variety of behaviours, such as resting, and stopping at old kill sites.

TABLE 3. A comparison of median Wolf travel distances (m/hr) at and away from ungulate kill sites (n = number of GPS locations) for three Wolves in separate packs during 2-15 March 2000 in west-central Alberta.

Wolf Pack	Travel at Kill (m/hr)	Travel Away from Kill (m/hr)	Mann-Whitney U test (P)
Cutbank	37 (n = 135)	148 (n = 48)≤	≤0.001
Prairie Creek	357 (n = 36)	338 (n = 159)	0.601
Simonette	37 (n = 116)	57 (n = 57)	0.067

However, these results are also lower than those reported by James (1999) for a boreal region of Alberta, where GPS collared Wolves moved 0.5 km/hr in the forest and averaged 1.4 km/hr on linear corridors. James (1999) collected GPS locations every five minutes with the objective of establishing Wolf speed, whereas in this study the collars obtained hourly locations with the purpose of establishing coarser estimates of Wolf travel distances in relation to kill sites. Frequency of locations can influence estimation of travel rates due to the linear extrapolation required between time intervals. In addition, the boreal region of Alberta has less topographic relief than the foothills of west-central Alberta, which could also account for some difference in Wolf travel rates. Finally, prey type and density, as well as pack and territory size could also influence movement patterns and resultant estimates of travel rates. Further investigation of these differences is warranted in order to better understand regional patterns.

The travel rate of Wolves in relation to ungulate kill sites provides important information when assessing predation risk to Caribou. Wolf travel distances were 4.2 less when near kill sites (45 m/hr) than when away from kill sites (190 m/hr). We suggest that differences in travel patterns between the three Wolf packs studied were likely due to the different prey species each pack was hunting. The Cutbank pack showed the greatest differences in travel at and away from kill sites and was found only at Moose kills. In one case, the pack remained near a cow Moose carcass for longer than four days, which reduced overall travel during the sampling interval.

The Simonette Wolf pack travelled marginally shorter distances when at, compared with away from ungulate kills. Their travel near kills was, in fact, the same as the Cutbank pack, but they travelled much less when away from kill sites. This result may be due to a combination of an overall high kill rate of ungulates (Kuzyk 2002) and partial consumption of prey (Carbyn 1983). As well, this Wolf pack made multiple kills of ungulates (e.g., Ballard et al. 1987; Mech et al. 1998) which would reduce their overall travel.

The Prairie Creek pack showed no difference in travel related to ungulate kills, with only one Elk kill being documented during aerial monitoring. This Wolf pack contained the fewest members (n = 5) during the study and pack size can affect ungulate kill rates (Fuller 1989; Schmidt and Mech 1997; Hayes et al. 2000). Nevertheless, it also likely that the Prairie Creek pack was preying on deer, as these Wolves were observed hunting deer on a number of occasions, although no deer kills were found (see also Carbyn 1974). Fuller (1989) discusses in detail the logistical problems of determining Wolf kill rates of deer, due to the short time frame in which Wolves handle deer carcasses and the difficulty in detecting Wolf-killed deer from the air. If deer are the main prey for the Prairie Creek pack, then Caribou may face greater predation risk in this territory, than in the territories of packs preying primarily on Moose, due to associated increases in travel and encounter rates. The extensive, recent logging in the area (Smith et al. 2000) could favour deer numbers, and thereby influence predation risk to Caribou. Wolves in this study area were found to use forest cutblocks proportionately more than unharvested forests, which may be a response to increased number of deer and other ungulates that are attracted to the young vegetation in the cutblocks (Kuzyk et al. 2004). A greater understanding of the role of deer in this Wolf-prey system is required, as most of the forest in westcentral Alberta has been allocated for timber harvest.

Projecting the long-term implications of ongoing development activities for Wolf-prey systems requires a more detailed understanding of the responses of all species to landscape change (Bergerud 1974), and both the functional and numerical response of Wolves to changes in ungulate prey abundance and distribution at relevant spatial scales (see Lessard 2005). The results of this study provide information on movement patterns of Wolves in relation to ungulate kills, which could be expanded by calibrating the more extensive GPS-database with signals detected from concurrent aerial observations (Franke 2004). This would result in a larger sample of potential kill sites for further analysis of predation patterns in relation to landscape features.

Acknowledgments

Funding for this research was provided by the West-Central Alberta Caribou Standing Committee, the Alberta Sport, Recreation, Parks and Wildlife Foundation, and a University of Alberta Challenge Grant in Biodiversity (supported by the Alberta Conservation Association). A University of Alberta Graduate Research Assistantship and the Margaret Brown Award in Environmental Studies and Wildlife Resources provided financial assistance to G. Kuzyk. We acknowledge the safe piloting conducted by Clay Wilson from Bighorn Helicopters and Denny Dennison from Coyote Air during wolf captures and monitoring.

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Received 4 February 2005
Accepted 14 December 2005

Added in proof

Franke, A., T. Caelli, G. Kuzyk, and **R. J. Hudson.** 2006. Prediction of wolf (*Canus lupus*) kill-sites using hidden Markov models. Ecological Modeling 197: 237-246.

Notes

Caching Behavior by Wintering Northern Saw-Whet Owls, *Aegolius acadicus*

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Devine, Arnold, and Dwight G. Smith 2005. Caching behavior in Northern Saw-whet Owls, *Aegolius acadicus*. Canadian Field-Naturalist 119(4): 578-579.

We observed 16 instances of caching behavior by Northern Saw-whet Owls in southern Connecticut between 30 October and 29 March over a 23-year period 1982 to 2004. Caches consisted of a single prey item in 13 instances and two prey items in three instances. Prey was cached either directly beneath the owl or from 5-28 cm distant, always on the same branch on which the owl was roosting. Observations of cached prey marked in the morning suggested that it was consumed after 14:30 in the afternoon of the same day. Such a delay indicated a true cache rather than delayed feeding.

Key Words: Northern Saw-whet Owl, *Aegolius acadicus*, caching behavior, Connecticut.

A cache is defined as a hiding place or storage site, particularly of food. In birds, caching is the act of placing excess food in storage for future consumption. Caching has been described for a number of species and is especially prevalent in certain raptors. We have observed caching behavior in Boreal Owls (*Aegolius funereus*), Eastern Screech-Owls (*Megascops asio*), Great Horned Owls (*Bubo virginianus*), and Northern Saw-whet Owls (personal obervations). In this paper we detail aspects of Northern Saw-whet Owl caching behavior that we observed at migratory and winter roosts in Connecticut in 1982-2004.

Northern Saw-whet Owl caching was noted by Cannings (1993), Catling (1972), and Bent (1938). Bondrup-Nielsen (1977) described thawing of frozen prey by captive Saw-whet Owls and discussed this behavior in relation to caching. Bent (1938) related Saw-whet Owl caching behavior noted by Bendire (1877), who stated that he fed several whole bird carcasses to a captive Saw-whet Owl which immediately ate their heads, afterwards covering the bodies with loose feathers in the corner of its cage.

We have previously described ecology and food habits of wintering Northern Saw-whet Owls in Connecticut (Devine and Smith 1994; Smith and Devine 1982); food consisted primarily of small mammals, mainly woodland mice (*Peromyscus* sp.), House Mouse (*Mus musculus*), jumping mice (*Zapus* sp.), shrews (*Blarina brevicauda* and *Sorex* sp.), chipmunks (*Tamias striatus*), and a variety of small birds, mostly species of sparrows and juncos.

We observed 16 instances of this caching behavior (Table 1) from 30 October to 29 March between 1982 and 2004. Each cache consisted of a single prey item in 13 instances and two prey items in three instances. Cached prey were all small animals, mostly rodents which is consistent with the Saw-whet Owl's reputation as a mouse predator. The majority (11 of 19 prey items or 57.9%) of cached prey were White-footed Mice (*Peromyscus leucopus*), but we also observed two House Mice, one Short-tailed Shrew, one Song Sparrow (*Melospiza melodius*), and one Pickerel Frog (*Rana palustris*), the last in October.

Cached prey were laid across twigs and branchlets beneath the owl's talons or within 5-28 cm. Most cached prey was within 5 cm of the roosting owl. The caching behavior that we observed is unlike that in other owls, which usually have a definite cache site. Instead, it sometimes resembles caching behavior exhibited by shrikes (*Lanius* species). To determine if these represented food caches or were simply prey to be consumed shortly, one of us marked prey (n = 6) on branches with food coloring dyes when first seen, generally at 07:00-09:00 hours and then checked the prey items in the afternoon of the same day, at 12:00-14:30 hours. In six instances, none of the food items had been consumed in these intervals. Follow-up visits the next day or two days later revealed that cache items were gone, presumably having been consumed either in the late afternoon or during that night.

At least 14 of the 19 prey were decapitated when first observed. Neither the unidentified sparrow nor frog had been decapitated and we were unable to determine the status of the three cached mammals because their anterior parts were partly covered by the owl's feathers.

Catling (1972) commented on caching by migrant Saw-whet Owls in Ontario. He suggested that owls

TABLE 1. Cached prey of Northern Saw-whet Owls in Connecticut, 1982-2004.

Species	October	January	February	March	Totals
White-footed Mouse (*Peromyscus leucopus*)		5	5	1	11
House Mouse (*Mus musculus*)	1		1		2
Short-tailed Shrew (*Blarina brevicauda*)		1			1
Masked Shrew (*Sorex cinereus*)			1		1
Golden-crowned Kinglet (*Regulus satrapa*)			1		1
Song Sparrow (*Melospiza melodia*)				1	1
Unidentified Sparrow			1		1
Pickerel Frog (*Rana palustris*)	1				1
Totals	2	6	9	2	19

consumed the heads of their prey during the previous night's hunting episode, and the body sometime during the following day. Our observations substantiate this possibility but suggest that the remaining prey is consumed much later the following day (after 14:30) and thus represents a true cache. We also note a distinct relationship between weather and Saw-whet Owl caching; caching was most commonly observed (13 of 16 instances) during the coldest months of the year, usually associated with periods of prolonged snow cover extending for 1-5 weeks.

Catling (1972) reported 31 instances of caching; 25 caches (80.6%) were during the migration period (defined as 1 October to 15 November and 15 March to 30 April) and six (19.4%) from the winter (15 November to 15 March. All 31 caches were decapitated and mice typically had forelimbs removed while birds had wings eaten. Our results differ markedly from Catling's. Using his criteria for winter and migration periods, we found 14 caches (87.5 %) during the winter and two caches (12.5 %) from the migration period. Furthermore we recorded two prey items at three different cache sites whereas this event went unreported by Catling. Thus caching appears to be an important survival mechanism of wintering Northern Saw-whet Owl in southern Connecticut.

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Received 28 July 2004
Accepted 15 September 2005

First Confirmation of Cougar, *Puma concolor,* in the Yukon

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Jung, Thomas S., and Philip J. Merchant. 2005. First confirmation of Cougar, *Puma concolor,* in the Yukon. Canadian Field-Naturalist 119(4): 580-581.

Cougar (*Puma concolor)* have been reported from the Yukon as early as 1944. Despite many sightings, no indisputable, physical evidence of Cougar being present in the Yukon had been obtained. Here, we report on the first. In November 2000, a specimen was secured from near Watson Lake, in southeastern Yukon. Whether this specimen, and the numerous sighting records, are indicative of a low-density breeding population in the Yukon, or represent transients, is unknown.

Key Words: Cougar, *Puma concolor*, Puma, Mountain Lion, Yukon.

The Cougar (*Puma concolor*) is one of the most widespread terrestrial mammals in the Americas, with their reported range extending from southeastern Alaska to Patagonia (Logan and Sweanor 2000). Globally, Cougars are classified by the IUCN (World Conservation Union) as Near Threatened, thus they require careful attention by wildlife managers. In the Yukon, Cougars appear to have naturally occurred only in recent history (<100 years), similar to other species such as Coyote (*Canis latrans*), Mule Deer (*Odocoileus hemionus*), and White-tailed Deer (*O. virginianus;* Youngman 1975; Hoefs 2001). The first reported Cougar sighting in the Yukon was in 1944. Since then, reported sightings, of variable reliability, have increased steadily. Despite local knowledge and expert opinion suggesting that Cougar were present in the Yukon, no physical evidence (e.g., scat, hair, confirmed tracks, photographs, or a specimen) had been found to substantiate any sightings. Here, we report the first irrefutable evidence of Cougar in the Yukon.

On 12 November 2000, a dead Cougar was discovered approximately 3 km NE of Watson Lake, Yukon (60.06°N, 128.70°W) by two local residents (E. Murphy-Kelley and J. Rhodes). The Cougar was found in a derelict car; apparently the abandoned car was being used as shelter by the Cougar. Interestingly, it appeared from tracks in the snow that there was another Cougar traveling with the one found. The Cougar appeared to have died shortly before being discovered, as it was not yet fully frozen despite temperatures being about -8°C.

The specimen was retrieved, measured, aged, and necropsied. Standard morphometric measurements were made using established protocols for Cougars (I. Ross personal communication) while the carcass was laid laterally. Skull measurements were taken from a cleaned skull. Aging was done by gumline recession (Laundré et al. 2000). A field necropsy was performed to determine the cause of death, and select organs and tissues were examined at the Western College of Veterinary Medicine (Saskatoon, Saskatchewan) for disease and other disorders. The specimen's hide was prepared as a mount and it is now in the collections of the MacBride Museum (Whitehorse, Yukon); the skull and skeleton reside with the Yukon Department of Environment (Whitehorse, Yukon).

The Cougar was an adult male that was estimated at >3 years old, and appeared normal except that it was emaciated – it weighed only 37.7 kg (males >2 years old normally weigh >53 kg; Logan and Sweanor 2000). Morphometric measurements were: total length = 223 cm; tail length = 83 cm; chest girth = 61 cm; high neck circumference = 40 cm; maximum neck circumference = 42.5 cm; right hind pad length = 41 mm; right hind pad width = 49 mm; head circumference = 50.5 cm. Skull measurements were: length = 217 mm; zygomatic breadth = 177 mm. No disease or other disorders were apparent. The stomach was empty and it is believed that the cause of death was starvation.

At the periphery of the Cougar's range, sightings are normally all that is available to judge whether a low-density or transient population of Cougars exists (e.g., Gerson 1988; Cumberland and Dempsey 1994; Stocek 1995; Gau et al. 2001), and this evidence, on its own, is inconclusive. Finding this specimen confirms that Cougars are occasionally found in the Yukon. Records also exist from adjacent jurisdictions: a specimen was obtained in Wrangell, Alaska, in 1989, there are an increasing number of sighting records in eastern and southeastern Alaska (Alaska Geographic Society 1996), and animals have been sighted (but with no corroborating evidence) west of the Mackenzie River in the Northwest Territories (Gau et al. 2001). Six unconfirmed Yukon sighting records include kittens (Yukon Department of Environment, unpublished data), suggesting a breeding population. Alternatively, Cougars seen in the Yukon may represent a few individuals (e.g., young males) that make long distance dispersals and are not indicative of a viable local breeding population (Pierce et al. 1999; Sweanor et al. 2000). In Wyoming, one radio-collared male Cougar is known to have dispersed >1000 km

(Thompson and Jenks 2005). Regardless, Cougars appear to be a rare but regular component of the mammalian fauna of the Yukon.

This confirmation of the addition of Cougar to the list of species in the Yukon is representative of the relatively dynamic state of the mammalian fauna of northern biomes. Other northern areas are also witnessing colonization by some species of large mammals. For example, Moose (*Alces alces*) and Coyotes are relatively new additions to the mammalian fauna of Labrador (Chubbs and Schaefer 1997; Chubbs and Phillips 2002). In the Northwest Territories, White-tailed Deer and Cougar also appear to be expanding northward (Veitch 2001; Gau et al. 2001).

Acknowledgments

We are grateful to E. Murphy-Kelly and J. Rhodes for promptly reporting this Cougar to wildlife officials. R. Hennings and D. Rudd retrieved the carcass. A. Baer, M. Hoefs, D. Rudd, E. Neufeld, and T. Grabowski assisted in processing and preserving the specimen. M. Oakley, D.V.M., undertook the necropsy and F. Leighton, D.V.M., tested the organs for disease and other disorders. D. Nagorsen, B. Slough, J. Adamczewski, and R. Maraj kindly provided helpful comments on an earlier draft. We thank the late I. Ross for assisting us with measurement and aging protocols.

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Received 2 February 2004
Accepted 19 September 2005

First Occurrence of the Round Goby, *Neogobius melanostomus*, in the St. Lawrence River at Cornwall, Ontario

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Hickey, M. Brian C., and Adrienne R. Fowlie. 2005. First occurrence of the Round Goby, *Neogobius melanostomus*, in the St. Lawrence River at Cornwall, Ontario. Canadian Field-Naturalist 119(4): 582-583.

We document the first reported occurrence of the Round Goby, *Neogobius melanostomus*, a small benthic fish native to the Black and Caspian seas, in the St. Lawrence River near Cornwall. On 7 September 2004, we observed approximately 20 Round Gobies while SCUBA diving at a depth of 7 m, downstream of the Saunders Generating Station at Cornwall, Ontario. Round Gobies appear to have arrived recently in this reach of the river and have not previously been detected despite extensive fish surveys conducted in the area.

Key Words: Round Goby, *Neogobius melanostomus*, exotic species, St. Lawrence River, Cornwall, Ontario.

The Round Goby, *Neogobius melanostomus*, is a small benthic fish native to the Black and Caspian seas (Charlebois et al. 2001). It was introduced to the Great Lakes from Eurasia in ballast water of trans-oceanic ships (Charlebois et al. 2001). The first reported sighting of Round Goby was in Lake St. Clair in 1990, and within five years, the species was reported in all five Great Lakes (Charlebois et al. 2001). Reasons for this rapid expansion include its high fecundity, wide tolerance of abiotic factors, and broad diet (French and Jude 2001; Corkum et al. 2004).

The Round Goby's expansion in to the Great Lakes has been rapid but movement into the St. Lawrence River has been much slower; perhaps an indication that habitat or hydraulic conditions are sub-optimal in the St. Lawrence. Gobies have been recorded upstream of the Moses-Saunders Dam as close as Prescott, Ontario (approximately 100 km upstream) and in the lower St. Lawrence near Quebec City. The geographic distribution of the Round Goby suggests that there have been at least two separate introductions but we are not aware of any studies that confirm this view. To our knowledge, they have not been previously recorded in the Cornwall area.

Their absence from the Cornwall area is probably a real phenomenon rather than the result of lack of detection. The St. Lawrence River between the Moses-Saunders Dam and the Beauharnois Dam in Quebec has been designated an Area of Concern (AOC) by the International Joint Commission. Consequently, the Cornwall area has been the focus of several ongoing biological investigations which have included regular surveys of the littoral zone fish community (Dreier et al. 1997; M. B. C. Hickey unpublished data). These surveys have included electrofishing, minnow trapping, and gill netting as well as snorkel and dive transects along an 8-km stretch of the St. Lawrence between the Moses-Saunders Dam and Windmill Point.

On 7 September 2004, we observed approximately 20 Round Gobies while SCUBA diving at a depth of 7 m, downstream of the Saunders Generating Station at Cornwall, Ontario (45°00'31"'N, 74°46'09"). The Round Goby's distinctive body shape and conspicuous dorsal fin spot (Figure 1) make it easy to distinguish from other small benthic fish reported from the St. Lawrence River (e.g., darters, *Etheostoma* sp. and sculpins, *Cottus* sp.). On two dives, less than 3 km downstream of the site where we observed round gobies on 7 September 2004, we did not notice gobies, suggesting that the gobies we observed represent the leading edge of their expansion in the St. Lawrence River as they move downstream from the upper St. Lawrence River.

The invasion of the Round Goby poses potential threats to native species such as the sculpins and darters that occupy similar habitat but are unable to compete for resources with the more aggressive gobies (Janssen and Jude 2001). The Round Goby's use of zebra mussels as a major prey may dramatically alter the patterns of contaminant uptake in the St. Lawrence River food web. The potential role of sediment contamination in the Cornwall "Area of Concern" (Dreier et al. 1997) is the subject of several ongoing investigations (M. B. C. Hickey and A. Fowlie, unpublished data). The introduction of Round Goby and subsequent lengthening of the food chain has been associated with increased levels of PCBs in fish of higher trophic levels in western Lake Erie (Morrison et al. 2000). The recent expansion of Round Goby in the St. Lawrence River AOC at Cornwall could produce similar effects in mercury biomagnification which has been shown to increase with food chain length (Cabana et al. 1994). Given the potential ecological and economic impacts of Round Goby invasion, the Cornwall area may provide a natural laboratory in which to study the impacts of the Round Goby and ultimately devise mitigation or control measures.

FIGURE 1. Round Gobies, *Neogobius melanostomus*, captured in the St. Lawrence River, immediately downstream of the Saunders Generation Station at Cornwall, Ontario. Photo by M. B. C. Hickey and A. R. Fowlie.

Acknowledgments

We thank Jason Szwec, Rob Marion and Jessica Roy for assisting us in the field and Jason Szwec and Rob Gratton for reviewing an earlier version of the manuscript. Sean Hickey and Lisa Hickey assisted with the capture of the Round Gobies photographed for Figure 1.

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Received 7 February 2005
Accepted 12 December 2005

Swift Fox, *Vulpes velox,* Den Located Next to a Railroad Track in Northwestern Texas

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Nicholson, Kerry L., Brady K. McGee, and Warren B. Ballard. 2005. Swift Fox, *Vulpes velox,* dens located next to a railroad track in northwestern Texas. Canadian Field-Naturalist 119(4): 584-585.

Swift Fox (*Vulpes velox*) dens are typically found in areas were the vegetation is sparse, in loam soils, and with unobstructed views of the surrounding area. In 2002 a Swift Fox in northwest Texas was found in a unique den situated at the base of a hill with the entrance within 1m of an active railroad track. Use of a den in such proximity to railroad tracks has never been previously reported.

Key Words: Swift Fox, *Vulpes velox*, den, Texas.

The Swift Fox (*Vulpes velox*) is one of the most burrow dependent canids in North America (Kilgore 1969; Hines and Case 1991; Jackson and Choate 2000; Harrison 2003; Uresk et al. 2003). The objective of this paper is to describe an unusual den site used by a Swift Fox in northwest Texas.

On 28 September 2002, we captured, radiocollared, and ear-tagged a juvenile female Swift Fox as part of a larger study on Swift Fox ecology (Nicholson 2004; McGee 2005). We monitored this fox until her death 16 April 2003. This fox was occasionally located in dens with another resident adult male on our study site. She was killed by an automobile while moving between her den and our study site to the south.

The female fox maintained five different den locations including an unusual den located next to railroad tracks. We tracked this female to the den on three separate occasions between 25 March and 16 April 2003. No other fox used this den. The railroad tracks cut through a hill with a den at the bottom of a 1-meter bank (Figure 1). The den was underneath a limestone rock shelf 23 meters from Highway 54, and 1 meter from the railroad. Approximately 0.4 km west of the den was an active granary and train stop; to the east were rangeland and crop fields. The embankments on either side of the railroad tracks were covered in yucca (*Yucca* sp.). There were 20–25 trains per day that traveled along the tracks between Stratford and Dalhart, Texas (D. Richard, Union Pacific Railroad, personal communication).

Visibility appears to be an important factor in den site and habitat selection for Swift Fox (Zoellick et al. 1989; Uresk et al. 2003). Unlike most Swift Fox dens, which allow for a clear view of the surrounding area, this den had limited (i.e., 1 m) visibility. The other four dens this female used were typical of Swift Fox dens in short vegetation, loam and clay-loam soils, and were surrounded by heavily grazed rangeland. Vegetation surrounding the railroad den (yucca taller than a fox), poor visibility (due to steep embankments), proximity to the railroad, and placement in a limestone rock shelf (dry, rocky soil) was uncharacteristic of previously described Swift Fox den sites.

We were not sure why this den site was selected but several explanations seem plausible. First, a lack of normal den sites or an over-saturation of foxes within the surrounding area may have limited this female's choices. We documented 35 different dens sites used by 20 monitored foxes on our adjacent study site. Also, this unusual den could have been refuge from predation. In our study site, Coyotes (*Canis latrans*) were heavily exploited by landowners and recreational hunters, yet Coyotes were responsible for 80% of Swift Fox deaths (Kamler et al. 2003). If there was risk from Coyotes, having a den site next to the train tracks may have deterred pursuit by Coyotes. This particular den was located outside previously documented Coyote home ranges (Kamler et al. 2003). For a Swift Fox, danger from Coyotes may outweigh the danger from trains. The use of this den could have been at first opportunistic shelter between divided range lands. It is probable that this den was constructed by some other animal like a Badger (*Taxidea taxus*) or Striped Skunk (*Mephitis mephitis*) and the fox came upon it while searching for other resources. This den was located slightly north of her natal home range and could have been a refuge den used in pre-dispersal exploration.

Previous research suggested that Swift Fox dens tended to be near roads (Hillman and Sharps 1978; Hines and Case 1991; Pruss 1999). Kamler et al. (2003) found that Swift Foxes seemed naïve to the threat of vehicles because they hunt in road ditches within a few meters of passing vehicles. Swift Fox mortalities due to vehicles suggested that foxes never learned to avoid vehicles (Kamler et al. 2004). Swift Foxes may regard trains in the same respect as vehicles, thus never

Figure 1. Picture of a swift fox den with an arrow indicating the entrance next to the railroad tracks in Sherman County, Texas, 2003.

actively seeking to avoid trains. Avoidance of Coyotes would be a reasonable hypothesis if Coyotes avoided railroad tracks.

Acknowledgments

This project was funded by the National Fish and Wildlife Foundation and Texas Tech University. We thank F. Pronger for allowing us to conduct studies on his land. We thank E. and B. Hampton for their endless support, and A. McGee and M. Green for data collection. Research protocols were approved by the Animal Care and Use Committee at Texas Tech University. This is Texas Tech University, College of Agricultural Sciences and Natural Resources Technical Publication T-9-1000.

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Received 29 March 2005
Accepted 27 September 2005

Water-bears from the Rocky Mountains: A First Look at Alberta's Tardigrade Fauna

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Boeckner, Matthew J., and Heather C. Proctor. 2005. Water-bears from the Rocky Mountains: A first look at Alberta's: tardigrade fauna. Canadian Field-Naturalist 119(4): 586-588.

There is no information in the published literature regarding Alberta's terrestrial water-bear (Tardigrada) fauna. We surveyed across an elevational gradient (1100 – 1800 ft) on Black Cat Mountain in the Alberta Rocky Mountain range. Ten taxa were identified from 902 specimens, all of which are new records for Alberta and one species is new for Canada: *Macrobiotus* cf. *islandicus* Richters, 1904. There was no clear relationship between elevation and tardigrade distribution, possibly owing to patchiness of these animals in the field and lack of adequate replication at each elevation.

Key Words: Tardigrada, elevation diversity, faunistic survey, Black Cat Mountain, Alberta.

Given the charismatic nature of water-bears (*Tardigrada*) and relative ease of collection, it is remarkable that so little is known about the ecology of Canadian tardigrades (see Boeckner et al. 2005 for a review of studies on Canadian tardigrades). Species lists exist for some Canadian provinces and territories; however, most records were compiled during patchy trans-Canadian surveys conducted in the early 20th century (Richters 1908; Murray 1910). British Columbia, Newfoundland and Labrador, New Brunswick, the Yukon and Northwest Territories have had the largest number of studies, British Columbia leading with five (Boeckner et al., 2005). Alberta, Manitoba, Nova Scotia and Prince Edward Island currently have no records of terrestrial tardigrades; however, a single study identified members of the genus *Hypsibius* in five Albertan lakes (Anderson and DeHenau 1980). Also, Murray (1910) collected tardigrades from the Rocky Mountains; however, it is unclear whether these samples were from Alberta or British Columbia.

The aim of this study was to begin the first of many forays that will result in a comprehensive list of Albertan tardigrade fauna. Additionally, elevation has been investigated as a factor affecting tardigrade assemblages (example: Guidetti et al. 1999). Thus, our data also provide information regarding distribution patterns across an elevational gradient.

Materials and Methods

The study was conducted on Black Cat Mountain (Figure 1) in the Rocky Mountain Foothills (Boule Range) east of Jasper National Park (53°18'N: 117°52'W). Moss samples (~250 ml each) were collected from eight sites along an elevational gradient. The lowest altitude sampled was 1100 m, the highest was 1800 m and samples in between were collected at altitudinal intervals of 100 m. The moss collected was *Pleurozium schreberi* (Brid.) Mitt., which is a widespread species common in dry forested areas (Johnson et al. 1995). Two sub-samples were collected at each altitude. Each of the 16 samples was placed in a separate paper bag for transport from the field.

Tardigrade extraction from the moss was achieved by using a Baermann funnel apparatus (Whitehead and Hemming 1965). This involved placing a sample of moss wrapped in cheesecloth in the cone of a blocked funnel. The funnel was then filled with water to submerge the sample. Live tardigrades migrate through the cheesecloth and collect in the water at the narrow base of the funnel. After 48 hours, the water from the base of the funnel was collected by removing the stopper. Any tardigrades remaining in the moss were separated by agitating the sample repeatedly in water. The water from both of these techniques was then combined and examined under a stereomicroscope (minimum 25×) for tardigrades and their eggs. Specimens were slide-mounted using polyvinyl alcohol medium (commercially available as PVA from BioQuip Products Inc., catalogue number 6371).

Identification of species was facilitated using the work of Ramazzotti and Maucci (1983). Hieronim Dastych (Zoologisches Institut und Zoologisches Museum, Universitaet Hamburg) and Nigel Marley (Faculty of Science, University of Plymouth) provided invaluable assistance by confirming the identities of voucher specimens.

Results

A total of 902 tardigrades representing seven genera and nine identifiable species were extracted from the 16 moss samples. Eighty-seven specimens were in poor condition and unidentifiable. Six of the species identified in this study (denoted by cf.) were from complexes composed of very similar sub-species (H. Dastych, personal communication). Tardigrade eggs are often required to identify sub-species within a complex. The tardigrades found in the greatest abundance were *Ramazzottius* sp. (N=247), *Macrobiotus* cf. *hufelandi* Biserov, 1991 (N=154), *Macrobiotus* cf. *richtersi* Murray, 1911 (N=107) and *Milnesium tardigradum* Doyere, 1840 (N=100). The *Ramazzottius* sp. may represent more than one species; however, without eggs this could not be determined. The remaining species were each represented by fewer than 100 specimens:

Hypsibius cf. *convergens* Urbanowicz, 1925 (N=79), *Macrobiotus* cf. *areolatus* Murray, 1907 (N=66), *Macrobiotus* cf. *islandicus* Richters, 1904 (N=29), *Echiniscus spitsbergensis* Scourfield, 1987 (N=23), *Isohypsibius* cf. *tuberculatus* Plate, 1888 (N=8) and *Platycrista cheleusis* Kathman, 1990 (N=2).

All 10 taxa are new records for Alberta. One species was a new record for Canada (McInnes 1994; Boeckner et al., 2005): *M.* cf. *islandicus*. *Platicrista cheleusis* has only ever been recorded previously in British Columbia (Kathman 1990). Table 1 shows the distribution patterns of the nine tardigrades identified to species and locations in Canada where they have been previously recorded.

An analysis of the distribution of species across an altitudinal gradient revealed only a few minor patterns. The third (1300 m) and fifth (1500 m) elevations contained the majority of specimens, 41% and 32%, respectively. Within these two altitudes *Ramazzottius* sp. dominated but was not found again within the other elevations. *Milnesium tardigradum* was relatively abundant in the third elevation but was not recorded elsewhere. Similarly, *M.* cf. *islandicus* and the one heterotardigrade identified, *E. spitsbergensis*, were found only in the lower elevations (1100 to 1300 m). *M.* cf. *hufelandi* exhibited the most even distribution across the gradient.

FIGURE 1. Location of Black Cat Mountain (X) in the Rocky Mountain foothills just outside of Jasper National Park.

Discussion

All 10 of the tardigrade taxa identified within this study were new records for Alberta and one species was a new record for Canada. The discovery of *M.* cf. *islandicus* was surprising given the limited distribution of this species reported in previous studies (Table 1). Ramazzotti and Maucci (1983) describe this species as neither frequently found nor hard to find suggesting that it may have a widespread distribution but generally low abundance. *Platycrista cheleusis* has previously found only on Vancouver Island, British Columbia (Kathman 1990). The remaining seven species are reported to have widespread to cosmopolitan distributions and therefore it is not surprising to identify them from Alberta mosses. It is important to note that although species designations are given here for most taxa, the lack of tardigrade eggs within the samples made some identification possible only to complexes of sub-species (denoted by cf.). Voucher specimens of each species were submitted to the University of Alberta freshwater invertebrate collection and are available upon request.

Table 1. Nine species of tardigrades new to Alberta and where previously recorded in Canada (adapted with permission from Bateman and Collins 2001). Distribution patterns as noted by Ramazzotti and Maucci (1983) and McInnes (1994). Locations: BC, British Columbia; L, Labrador; NB, New Brunswick; NF, Insular Newfoundland; NWT, Northwest Territories; ON, Ontario; PQ, Province du Quebec. Recorded by: A, Argue (1971, 1972, 1974); B&C, Bateman and Collins (2001); B, Boeckner et. al. (2005); I, Iharos (1973); K, Kathman (1990); M, Murray (1910); P, Pilato (1977); R, Richters (1908); VR[1], Van Rompu et al. (1991); VR[2], Van Rompu et al. (1992).

Species	Canadian Records	Distribution
Echiniscus spitsbergensis	NB (A), NWT (VR[1,2])	widespread
Macrobiotus cf. *areolatus*	BC(M,K), NB(A), ON(M), RM(M), SK(P)	cosmopolitan
M. cf. *hufelandi*	BC(R,M,K), L (B), NB(A), NF(B&C), ON(M), PQ(I), RM(M)	cosmopolitan
M. cf. *islandicus*	**new Canadian record**	Europe-Iceland
M. cf. *richtersi*	BC(K), NB(A), PQ(I),	cosmopolitan
Hypsibius cf. *convergens*	BC(K), L (B), NB(A), NF(B&C), NWT(VR[1,2])	cosmopolitan
Isohypsibius cf. *tuberculatus*	BC(M), NB(A)	widespread
Platycrista cheleusis	BC(K)	Canada-BC
Milnesium tardigradum	BC (R, K), L (B), NB (A), NF(B&C), ON(M), PQ(I)	cosmopolitan

The analysis of tardigrade distributions across an elevational gradient produced only weak patterns. This was likely owing to lack of adequate replication at each elevation and natural variation in tardigrade abundance and distribution (patchiness). Furthermore, sample sites were likely variable in more ways than elevation alone (i.e., exposure, substrate type, moisture, etc.). Generally, *M.* cf. *hufelandi* tended to have a more uniform distribution throughout most elevations when compared with the other species. Additionally, *Echiniscus spitsbergensis* and *M.* cf. *islandicus* had distributions limited to lower elevations. It remains to be determined whether these general trends are indicative of actual altitude-constrained distributions.

Although this study has identified a fair number of Albertan tardigrades there are vast areas of the province that have yet to be surveyed. Until such investigations are made it is impossible to comment confidently on species ranges.

Acknowledgments

We thank Hieronim Dastych and Nigel Marley for lending their outstanding expertise in tardigrade identification to this study. Much appreciation is also extended to Kevin McEwan and Danica Belter who aided in collection and extraction of the samples. We gratefully acknowledge the financial support of this research by the Natural Sciences and Engineering Research Council Discovery Grant held by Heather C. Proctor.

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Received 15 August 2004
Accepted 14 November 2005

***added in proof 2006** 1105: 1-16

Mortality of Little Brown Bats, *Myotis lucifugus*, in a Rodent Trap in the Boreal Forest

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Jung, Thomas S., and Brian G. Slough. 2005. Mortality of Little Brown Bats, *Myotis lucifugus*, in a rodent trap in the boreal forest. Canadian Field-Naturalist 119(4): 589-590.

Accidental mortality of bats is not often observed or reported in the literature. It may, however, have an impact on population size and structure. We report an observation of 53 Little Brown Bats (*Myotis lucifugus*) being trapped and drowned in a homemade rodent trap at an abandoned cabin in southern Yukon. Traps of this design may be commonly used in the boreal forest. We recommend not using such traps in cabins that are used by colonies of bats.

Key Words: Little Brown Bat, *Myotis lucifugus*, mortality, trap, Yukon.

Accidental mortality of bats is not often observed or reported in the literature (Johnson 1933; Manville 1963). Among the causes of mortality indirectly caused by humans (i.e. unintentional, or accidental mortality), several have been noted for bats. For example, poisoning (e.g., Kunz et al. 1977; Clark et al. 1978; Pybus et al. 1986), human disturbance at roosting colonies or hibernacula (e.g. Tuttle 1979; Thomas 1995; Johnson et al. 1998), entanglement in exotic burdock (*Arctium* spp.; e.g., Lyon 1925; Hendricks et al. 2003), and collisions with wind turbines (e.g., Johnson et al. 2003), have been noted as observed or potential causes of accidental mortality. Curiously, few other sources of accidental mortality have been reported for bats. Yet, in some cases, accidental mortality may have an effect on colony size or structure that is equal to or greater than natural mortality (i.e., predation, disease, starvation, etc). Here, we report an observation of mortality of Little Brown Bats (*Myotis lucifugus*) in a homemade trap that is commonly used in buildings in the Canadian boreal forest to capture mice (*Peromyscus* spp.).

On 8 September 2004 we found 53 dead and desiccated Little Brown Bats in a rodent trap in a cabin near Squanga Lake, Yukon (60.5°N, 133.5°W). We were unable to reliably ascertain the age or sex of individuals. The specimens have been retained by the Yukon Department of Environment. No rodents were found in the trap.

The cabin was abandoned and housed a maternity colony of Little Brown Bats since at least 2000 (Slough 2001*). Colony size before this incident of mortality was estimated at about 85-100 adults on 29 June 2004 (Jung and Slough, unpublished data), based on emergence counts and captures with a harp trap (Tuttle 1974). The rodent trap was prominently placed in an empty room that was regularly used for flight activity by bats after arousal and before they exited the cabin.

The rodent trap was homemade and of a design that is commonly used in the Canadian boreal forest where remote cabins are left unoccupied for several months at a time, particularly by seasonal trappers, hunters, and fishers (H. Jessup, personal communication). These traps are regularly made of 19 litre (5 gallon) buckets

FIGURE 1. Homemade "bucket" trap with 53 mummified little brown bats (*Myotis lucifugus*). Note the wire and rotating bait can that was used on the trap, but removed for this photograph.

(31.4 cm in diameter by 38.7 cm tall) that are half-filled with water. A wire or rope is strung across the top opening of the bucket and a beverage can (approximately 335 ml) is placed along the middle of the wire or rope. Rodents walk along the rope to reach bait that is placed in the can and fall into the bucket and drown. The trap is designed to catch multiple rodents, primarly *Peromyscus*.

We suspect that Little Brown Bats attempted to drink from the bucket upon arousal from diurnal roosting and became trapped and drowned. Some bats, including Little Brown Bats, routinely drink after diurnal roosting bouts and before foraging. Alternatively, some bats may not have attempted to enter the bucket to drink, but had tripped on the wire while flying low above the bucket and fell into the bucket and drowned. Trip-lines over water have been used as a live-capture technique for bats. Regardless, we believe that the water in the bucket was likely the attractant that led to bats

becoming trapped and drowning in the bucket. It is plausible that the distress calls of one bat trapped in the bucket attracted conspecifics, which then shared the same fate (Barclay 1982; B. Fenton, personal communication). Hendricks et al. (2003) suggested a similar scenario for multiple bats becoming entangled in burdock.

Because Little Brown Bats tend to have long life spans and low annual productivity (Fenton and Barclay 1980; van Zyll de Jong 1985), it is reasonable to suggest that accidental mortalities may, in some cases, have a substantial effect on colony size or structure. We suspect that this incident of accidental mortality may have substantially reduced the size of the Squanga Lake colony. We do not know how common it is to capture bats in this type of rodent trap, but suspect that it may happen somewhat regularly, with unknown effects on Little Brown Bat populations in remote boreal forest ecosystems. We strongly recommend that rodent traps of this or a similar design not be used in buildings when they are occupied by colonies of bats.

Acknowledgments

We thank B. Bennett for helping us solve the mystery of "how the bats got in the bucket". Financial support was provided by the Yukon Department of Environment and a Northern Research Endowment Grant from the Northern Research Institute, Yukon College.

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Received 18 March 2005
Accepted 26 October 2005

Beavers, *Castor canadensis*, Feeding on Salmon Carcasses: Opportunistic Use of a Seasonally Superabundant Food Source

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Gleason, Jeffrey S., Ryan A. Hoffman, and James M. Wendland. 2005. Beavers, *Castor canadensis*, feeding on salmon carcasses: opportunistic use of a seasonally superabundant food source. Canadian Field-Naturalist 119(4): 591-593.

We report observations of Beavers (*Castor canadensis*) foraging and feeding on discarded Chinook Salmon (*Oncorhynchus tshawytscha*) carcasses within the confines of the Susitna River drainage in southcentral Alaska on three separate occasions between 1999 and 2004. In all three instances, Beavers were observed actively seeking out freshly discarded carcasses or transporting "fresh" salmon carcasses in their mouths. In one instance, Beavers were seen using their dextrous forefeet to "handle" chunks of salmon while hunched over carcasses and in this case we actually witnessed Beavers "chewing" and ingestion was assumed. In the other two instances, Beavers were observed swimming with salmon carcasses in their mouths. Though unique within the framework of Beaver foraging ecology, we suggest this behavior may be a fairly common strategy employed by Beavers in Alaskan streams and rivers to take advantage of a seasonally superabundant source of protein.

Key Words: Beaver, *Castor canadensis*, Chinook Salmon, feeding, *Oncorhynchus tshawytscha*, Alaska.

Many herbivorous mammals are known to ingest animal matter either occasionally or on a seasonal basis, (i.e., mice [*Peromyscus* spp.; Barry 1977; Lackey et al. 1985], Red Squirrels [*Tamiascirius hudsonicus*; O'Donoghue 1994; Steele 1998; Yahner 2003] and Northern Flying Squirrels [*Glaucomys sabrinus*; Wells-Gosling and Heaney 1984], Muskrats [*Ondatra zibethicus*; Willner et al. 1980; Campbell and MacArthur 1996; Erb and Perry, Jr. 2003], and White-tailed Deer [*Odocoileus virginianus*; Shaw 1963; Case and McCullough 1987; Pietz and Granfors 2000]). However, such observations are lacking for Beavers (*Castor canadensis*). The Beaver is considered a generalist herbivore, relying primarily on woody and herbaceous materials throughout its range to meet its energy requirements (Jenkins and Busher 1979; Novak 1987; Baker and Hill 2003; Muller-Schwarze and Sun 2003). Unlike other herbivorous mammals that are known to ingest animal matter to meet seasonal food shortages or sex and age-specific nutrient requirements (Robbins 1993), observations of carnivory are lacking for Beavers. We report here on observations of Beavers feeding on animal matter in the form of Chinook Salmon (*Oncorhynchus tshawytscha*) carcasses and discuss the potential importance of this readily available food source to Beavers in Alaska.

On 5 July 2004, at around 0800 AST, we observed three Beavers feeding on Chinook Salmon carcasses discarded after being filleted by anglers along a relatively deep-water pool of Montana Creek located roughly 200 m upstream of the Parks Highway bridge (150°03'W, 62°06'N). The upper reaches of this creek and others in the Susitna River drainage represent important spawning areas for Chinook Salmon in the region. This stretch of the stream opened to salmon fishing on 3 July. Beavers fed on freshly discarded carcasses aground in shallow areas upstream and downstream of the pool where the Chinook Salmon were holding. This pool was roughly 1.5 m at its deepest and was approximately 18 × 46 m in size, bounded on its upper and lower ends by shallow-water riffles. A variety of both woody (willows [*Salix* spp.], birch [*Betula* spp.], alder [*Alnus* spp.]) and herbaceous vegetation [sedges (*Carex* spp.)] were abundant within the creek corridor. Weather conditions on this date were sunny to partly sunny with temperature ranging from 15 to 20°C and no precipitation. The Beavers we observed appeared to be adults (based on their relatively large body size) and they fed for approximately 10-15 min on a carcass before moving on to another carcass. Foraging and travel between carcasses occurred nearly continuously for about 60 min in close proximity (5 m) to the observer (RAH). Chewing was evident as the Beavers fed while hunched over carcasses using their forefeet to "handle" chunks of remaining salmon muscle tissue (not organs).

On two previous occasions approximately 6 km from the location of the above incident, we (JMW) observed apparent foraging behavior by Beavers that also involved Chinook Salmon. Two Beavers on 12 June 1999 (07:00 ADT) and 2 on 17 June 2000 (04:00 ADT) swam from the Susitna River upstream into Goose Creek (150°05'W, 62°03'N) about 20 m to the edge of a 1.5 m deep pool. The creek was roughly 30 m wide and vegetation composition along the creek was similar to that previously described for Montana Creek. The Beavers, which all appeared to be adults, picked-up recently filleted Chinook Salmon carcasses discarded by anglers that were aground at the edge of the pool. The Beavers swam downstream from the pool into the Susitna River channel each with a carcass in its mouth. In addition, on 17 June 2000, we (JWM) observed a Beaver actually bite into an intact Chinook Salmon that was hanging from an angler's stringer. The

angler and Beaver struggled briefly before the angler finally freed his catch. This bout resulted in two large (10–12 cm) gashes inflicted on the salmon from the Beaver's incisors.

We are unaware of other published observations of Beavers feeding on animal matter (see Jenkins and Busher 1979; Baker and Hill 2003). Given their morphological and physiological adaptations for feeding on woody and herbaceous vegetation (e.g., massive skull, dentition and large incisors, bacteria in cecum; Jenkins and Busher 1979; Novak 1987; Baker and Hill 2003), this observation seemed significant in the context of Beaver foraging ecology. We assume that ingestion of salmon muscle tissue occurred for at least one of the three observations since chewing was seen. We speculate that opportunistic feeding on salmon may not strictly be limited to Beavers in this watershed, but rather that it may be widespread in Alaskan rivers and streams where Beavers overlap large spawning runs of Pacific salmon. In fact, during our research we spoke with others (R. Prentki, Minerals Management Service) within the region who witnessed similar observations. We hypothesize that Beavers in Alaska and presumably elsewhere in the Pacific northwest may opportunistically use or even actively seek out "fresh" (not senescent) salmon carcasses as a readily available and predictable (both in space and time) source of energy (i.e., protein or fat), at least on a seasonal basis (Gende et al. 2001; 2004b; Hilderbrand et al. 2004). Salmon carcasses, including discarded carcasses from anglers, represent a large, seasonal nutrient (particularly ^{15}N) input into anadromous systems in Alaska and elsewhere (Cederholm et al. 1999; Hilderbrand et al. 1999; Helfield and Naiman 2001; Reimchen et al. 2003; Gende et al. 2004a). A diverse assemblage of birds and mammals utilize pre-spawning (predation) and post-spawning (scavenging) salmon for food (Willson and Halupka 1995; Hilderbrand et al. 2004). For example, Cederholm et al. (1989) documented forty-three taxa of birds and mammals on salmon streams in Washington, and of these 51% were thought to have consumed salmon. Thus, it is not surprising that many animal species including apparently Beavers, exploit this seasonally superabundant high energy food source.

Acknowledgments

This manuscript benefited greatly from discussions with Howard Golden (Wildlife Biologist, Alaska Department of Fish and Game). H. Golden and K. F. Abraham (Wetlands Wildlife Scientist, Ontario Ministry of Natural Resources) provided comments on an earlier draft of this manuscript. Two anonymous reviewers provided suggestions that greatly improved the manuscript.

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Received 4 November 2004
Accepted 5 December 2005

Book Reviews

ZOOLOGY

Arrivals and Rivals: A Birding Oddity

By Adrian Riley. 2005. Brambleby Books, PO Box 410, Harpenden, Hertfordshire, AL5 5XQ UK. 165 pages. £7.99 paper.

Many of you will know I am not a lister (or twitcher as they are called in Britain.). I am nowhere near competitive enough. I really do not care if you have seen more than me, as long as I see what I want to see. This is a book about the author's efforts to meet the ultimate twitcher's challenge – to become the British Twitcher of the Year. So I was intrigued as to why he did it and against what social backdrop.

The author starts his year with his retirement and a consequent move to Norfolk. Now Norfolk is a very good location for a birdwatcher as it has an interesting list of annual birds and gets a great number of vagrants. The author starts his year as a very keen birder who keeps an annual list. His early partnership with an avid twitcher nets him a very respectable winter list by the end of February. His retirement allows him the time to chase many rarities, particularly those on his new back door step.

Then his tone starts to change as he become more greedy for ticks. He pushes himself harder and farther to add a new bird. He finds he has become a "combat "birder, where the tick transcends everything else. Friendships pull apart and then become bitter and paranoid. He becomes over-emotional and over-tired. The competition becomes a war and many of the joys of birding fall to the wayside. The end of December comes as a relief. The fighting is over and he has won with a tally of 380 compared to the 573 on the official list of birds of Great Britain sanctioned by British Ornithologists' Union's Records Committee (BOURC).

His total is over two-thirds of the British list. Or is it? He includes one bird that had not made it to the official list by November 2005 (Elegant Tern, although this California to Chile bird is on the Irish list – and it appears "Britain" still includes Ireland for ticklisters. The BOURC however states "Species recorded from the Republic of Ireland (jurisdiction of the Irish Rare Birds Committee (IRBC)) and the Channel Islands are not covered in any reports or lists produced by the BOURC). There are two species (Baikal Teal and White-headed Duck) for which there is "reasonable doubt" and therefore "they form no part of the British list" (quotation marks are BOURC text). He has also added five species whose taxonomy as a full species is still in debate. Again the BOURC has not seen fit to add them at this time. BOURC has split redpoll into three species, but most authorities, including the American Ornithologists Union and Birdlife International, recognize only two species saying the taxonomy of the Lesser Redpoll is no longer valid. His total is submitted for scrutiny, but I am not clear who does this or what reference they used to make his list "official."

I was amazed at how well-organized rarity chasing is in Britain. Although the author does not explain the system, I deduced there is a manned Rare Bird Alert (RBA) that accepts and vets calls, issues bulletins by pager and keeps the information up to date. This means a birder chasing a vagrant in the far north can receive an alert with instructions and drive to the south coast for another tick on the same day!

The cost of this epic is that he has seen the darkest side of himself and others. Withholding or obscuring RBA information is only part of the "game." He endured a great deal of discomfort, potential legal action, sloshing through that awful British weather and in driving many long, lonely hours. As well it cost him friendship and about $16 000 Canadian.

To his credit, he maintained a sense of humour and never really lost the true meaning of birding (although you had to wonder on occasions!). He also never lowered himself to questionable sightings or inclusions. Questionable practices is a different question.

I was amazed at the number of vagrants that turned up in Britain in a single year. Over 30% of his ticks were single sightings and another 11% were two sightings only.

I was truly fascinated by this book. It is certainly a book for all birders – sane and insane – and definitely a must for all marathon twitchers. I enjoyed the writer's style and I hope he takes on a new project with a different, more valid objective that leads to another book (perhaps he could retrace the steps of Henry Seebohm; Siberia in Asia: A Visit to the Valley of the Yesnay in East Siberia, with Description of the Natural History, Migration of Birds, etc. 1882?). Then he would avoid adding his last sentence in the book – "In the end, it matters not a jot."

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Band-tailed Pigeon: Wilderness Bird at Risk

By Worth Mathewson. Timber Press, Portland, Oregon. 2005. Hardcover. 183 pages, 20 colour photographs, 23 black-and-white figures, 4 tables. $19.95 US.

Ward Mathewson has been studying the Band-tailed Pigeon for 48 years, first as one who hunted them and enjoyed eating pigeon pot-pie, and later as a conservationist trying to save the species. We learn much about the year-round habits and habitat of this beautiful bird. It breeds north to extreme southwestern British Columbia, but occasional individuals wander farther north and east, into the three prairie provinces. Mathewson has searched the literature carefully, and cites three Saskatchewan bandtail records in the *Blue Jay*. In keeping with other dove species, the bandtail builds a flimsy nest and the female generally lays a single egg. Favourite foods are berries of the cascara and elder; because of the extremely high potassium content of those berries, bandtails have a physiologic need to visit mineral springs with a compensatory high sodium (and calcium) content.

Initially, in the 1890s bandtails were subjected to netting and shooting over decoys for distant markets. As late as 1912, a train would bring 100 hunters to a choice habitat and they would shoot an average of 30 birds each. One hunter shipped 2000 bandtails to hotels in California during the winter of 1911-1912. Until farmers learned to drill seeds into the ground, this pigeon was persecuted for eating a high proportion of hand-sown seeds spread on the ground. Later, bandtails destroyed up to nine-tenths of cherries in a grove until the farmer invited 500 hunters to shoot the bandtails. In subsequent years, sport hunters often concentrated their efforts at mineral springs and in mountain passes through which bandtails migrated.

There were early warnings about declining numbers. Johnson Neff in California in 1932 and 1934 warned that as few as one in five bandtails mortally shot were actually retrieved by the hunter. Art Einarsen in 1946 reported than at one prime 10-acre bandtail hunting site near Crawfordsville, Oregon, 10 000 shells had been fired at a 10-acre shooting site. Gene Silovsky determined in 1969 that 52 of 74 males and 48 of 82 females shot in the fall hunting season were actively producing pigeon milk, hence were feeding squabs; young inevitably died if no parent returned to feed them. Government game departments simply ignored such research results.

In 1975, when the new Oregon Fish and Wildlife Commission was formed, author Worth Mathewson began his campaign to have shooting stopped at the few mineral springs where bandtails concentrated. He felt shooting here during the first two weeks of September led to unsporting slaughter, certainly not "fair chase," as waves of males and then females fell to the concentrated hunters' guns. As numbers declined, the daily bag limit was lowered from eight to five birds per day, without apparent effect. In 1980 and 1981, the opening day was delayed two weeks to 15 September, to a time when fewer squabs were being fed; there was a noticeable increase in the population index. But self-interest of the bandtail shooters persuaded the state to change the opening date back to September 1 for eight more destructive years. In 1989, the 15 September opening was restored, the season length was shortened to seven days and the bag limit reduced to two birds, yet despite these changes a federal Fish and Wildlife Service biologist observed that "We're going to 'do-nothing them' into extinction." By 1991, numbers had dropped so much that British Columbia and Washington closed their seasons. The bandtail had been a victim of stupidity, ignorance, misrepresentation, and inattention to research findings.

Meanwhile, forest companies which wanted a higher harvest of conifers, began large-scale aerial spraying of broad-leaved trees in the 1970s. The Nehalem Valley, a bandtail stronghold, became solid conifers, with the elderberry and cascara apparently gone forever.

This book is much more than the frustrating crusade by Mathewson on behalf of the Band-tailed Pigeon. It is also an example of investigative journalism at its best, well-documented and convincing. Mathewson shares with us the inside stories, and compares the bandtail situation with that of other doves and pigeons, including the extinct Passenger Pigeon, and the decreasing numbers of the White-crowned Pigeon, White-winged Dove, and Key West Quail-Dove. Meanwhile, in Argentina 210 shooters tallied 408 643 Eared Doves in one season, described by Mathewson as "mindless killing without justification." As late as 2003, an issue of *Gray's Sporting Journal* carried an advertisement picturing a shooter kneeling on 7696 Eared Dove carcasses!

The writing is both lyrical and descriptive, a pleasure to read. Sketches by David Hagerbaumer add to the attractiveness of this book.

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Monitoring Bird Populations Using Mist Nets: Studies in Avian Biology #29

Edited by C. John Ralph and Erica H. Dunn. 2004. Cooper Ornithological Society, c/o western Foundation of Vertebrate Zoology, 439 Calle San Pablo, Camarillo, California 93012-8506 USA. 211 pages. U.S.$39.95.

A workshop was held in California in October 1993. Forty experts (six from Europe, five from Canada, including one of the two editors, and the remainder from the United States and Puerto Rico) evaluated the strength and weaknesses of mist-netting as a method of monitoring bird populations. Six additional individuals contributed to the papers, incorporating new data and updated analyses prior to final editing – which occurred only after a remarkable delay of ten years.

As stated by the editors in their Introduction, the advantages of mist nets include ease of standardized sampling, low observer bias, ability to detect species that are often missed (sometimes including rarities unlikely to have been spotted by routine observation), and the opportunity to examine birds in the hand. Mist net studies, as do other visual and aural methods, provide indices of abundance rather than total counts of populations.

Three programs with some variation in methodologies, but using mist-nets in a standardized fashion, are the MAPS (Monitoring Avian Productivity and Survivorship) Program pioneered in California by David DeSante and now spreading across the continent, the British Trust for Ornithology's Constant Effort Sites Program, and the MRI Program in continental Europe (named from the first letter of the three initial sites, since expanded to seven). All three methods have the potential to detect long-term temporal trends. Sampling only at weekends should be avoided.

Two major papers deal with 18 years of data collected at Long Point Bird Observatory in Ontario. At Beaverhill Bird Observatory in Alberta, six participants in an informal banding training program failed to attain fully satisfactory performances. Summary recommendations, to produce as much information as possible with the lowest bird mortality, include training of all participants, checking the nets every 15 to 30 minutes, and use of 30- and 36-mm-mesh nets that are 12 m long.

This volume is a must for anyone using mist nets, and for Bird Observatory libraries.

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Portraits of the Bison: An Illustrated Guide to Bison Society

By Wes Olson. 2005. The University of Alberta Press, Edmonton. 108 pages. ISBN 0-88864-432-9. Paperback. $39.95.

Bison are the iconic animal of the Canadian prairies. If you live in western Canada, then pictures of bison – being hunted, as piles of skulls by train tracks, as a provincial symbol – are woven into your consciousness. Yet, most people know little about them. It is this deficiency that Wes Olson has set out to remedy with this full-colour guide. Olson has worked as a park warden at Elk Island National Park, located just east of Edmonton, for many years. Despite its name, the Park is probably best known as the home of two bison herds, one of plains bison and the other of wood bison. Olson's experience in working with these herds has given him unique insight into the social structure and biology of the animals. At the same time, his interactions with park visitors have made him aware, as he explains in the introduction, that most people do not treat bison with the respect they deserve and thus sometimes get themselves into dangerous situations. These are the two incentives that encouraged him to compile this volume. Wes Olsen is a talented artist and the book is abundantly illustrated with his drawings of bison, providing vivid evidence of keen observation and long study. His wife, Johane Janelle, contributed many outstanding colour photographs, capturing bison in different moods and surroundings.

The book is arranged in four chapters. Olson provides a short introduction to bison and notes the occurrence and ranges of the two main modern forms, plains and wood bison. Interestingly, he describes the capture and establishment of the wood bison herd, but does not go into the history of the plains bison recovery in any detail. I found this omission curious, given that the rest of the volume concentrates on plains bison, especially since saving the bison from the brink of extinction is a classic conservation story. The second chapter focuses on safety and awareness for hikers and others who might run into bison in the field. Olson describes the stages of a bison's reaction to an encounter with a human. He emphasizes that bison have a very large "personal space" and should be given an extremely wide berth. Olson identifies three zones within "bison space" – the awareness zone, the escape zone, and the fight zone – and indicates what a bison's behaviour may be when a human impinges on each of these zones.

The next two chapters comprise the heart of the book. The first is focused on the seasonal cycle and structure of bison herds. This makes it clear that bison have a complex social structure, related to biological events, such as calving and the rut, and the life-stages of the animals. The next chapter provides more detail on the life-stages of a male and a female plains bison. This is the longest chapter (34 pages) and is richly illustrated with page by page pictures of bison, usually acutely-detailed profile drawings with the salient identifying features indicated. Olson comments that distinguishing male and female bison is not as straightforward as one might think, especially when the bison

are seen at a distance or in a large group. For example, although males are usually larger than females, this size difference is not as marked in younger animals. Olson distinguishes seven life-stages for bison: calves, yearlings, two-year-olds, young adults, mature adults, dominant males, and aged bison. He points out that for wildlife biologists, knowing the age structure and composition of a bison herd is important for making management decisions. However, recognizing different generations of bison can also add interest to a hike or nature ramble. Just as birders recognize birds by plumage and songs, bison watchers must learn to distinguish different pelage stages, body structure, and horn shapes.

The book continues with four appendices, focusing on age and sex determination from the skull, a list of public bison herds in North America, a summary reiterating the main features of male and female life stages, and a blank data sheet for recording observations on bison herd structure. The age and sex determination focuses on a few critical plains bison skull measurements and tooth eruption and wear patterns in the lower jaw or mandible. Olson mentions one criterion for distinguishing bison from cattle skulls. I found this section a bit brief. Within a national park or a wildlife refuge with a bison herd one can assume that skulls are mostly going to be from bison. However, this is not the case across the prairies at large, where people often find skulls, or more usually parts of skulls, that they think may be bison. I felt that more information on distinguishing bison from other faunal remains would have made this section more generally useful. The volume concludes with a helpful reference list, comprising many general and scholarly works on bison behaviour and biology. The book is large-format (27.5 cm wide by 25.5 cm high), giving plenty of space for the photographs and drawings, and is printed on high-quality glossy paper. The images are well laid-out and, for the most part, crisply rendered.

This is an unusual book. I certainly have not come across anything quite like it before. It is not really a field guide, since the format does not lend itself well to being stuffed in a pocket. It is not really a text book, because the emphasis is on identification, observation, and field work. This book will certainly be relevant to anyone who works with bison in the field or has an interest in bison population studies, wildlife biology, or ecology. However, I think it has much broader appeal and will also intrigue anyone who simply likes watching bison and wants to learn more about them. The book can also be enjoyed on a purely aesthetic level, because the photographs and drawings are in themselves so attractive and fascinating. Those of us fortunate enough to live near Elk Island National Park can see bison in the flesh, large lumbering presences moving through aspen groves, or dozing in summer sunlight. Armed with information from this book, bison spotting can have another dimension, as you try to work out who's who in the herd.

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The Buffalo Wolf, Predators, Prey and the Politics of Nature

By Lu Carbyn. 2003. Smithsonian Books, Washington, D.C. USA. 248 pages. U.S.$24.95. Cloth.

"It might be said that the wolf was one of the last natural resources to be included in the great modern movement toward conservation." This statement appeared in the late 1960s in one of the most impressive and enjoyable books about wolves that has ever been written (Rutter and Pimlott 1968). Conservation has come a long way, both generally and specifically with regard to the wolf. People who have led the way are few in number. Lu Carbyn is one of them. His devotion to conservation and wilderness is evident in this book which centres on wolves and bison in the Peace-Athabasca delta region of Wood Buffalo National Park.

The first chapter contains some very graphic descriptions of wolves attacking and killing bison. This is disturbing, but the reader is challenged to accept that the health of the ecosystem lies in the survival of the predators. In contrast, the second chapter sets the stage, describing Wood Buffalo Park and providing some biological background. The real story begins with the third chapter. It presents observations made during the early days of the research in Wood Buffalo Park. The social structure of the pack as it relates to the interactions with bison is described in some depth. The fourth chapter outlines some of the fascinating results of aerial surveys. Chapters 5, 6, 7 and 8 mostly have to do with field studies that followed the termination of the Canadian Wildlife Service program in 1984. Adventures with film crews are a major feature.

Chapter 9 includes some experiences during later solo visits to the delta. The debate over whether or not to eradicate the Wood Buffalo bison herd is the main focus of the last three chapters. This debate had its origin in the introduction and "contamination" of the park's wood bison with plains bison stock from Wainright. Not only were the park bison impure, they carried diseases that also infect cattle. On the other hand there may always have been hybrids and maybe it is unlikely that herds can be protected indefinitely from some or all diseases so better to let nature take its course. Alleged declining numbers of bison in the park fanned the fire of eradication, but "how much management is too much?" After years of first hand study Carbyn believed that the wolves were the main factor in the fluctuating numbers of bison but he pointed out that parts of the big picture are still not avail-

able and more information is needed to predict the future of the park bison. The author cleverly leads us through this debate showing how views changed and how personal agendas and politics have played a role at the expense of science. He concludes that "if other human priorities are set in place, then enlightenment, not agendas, should rule the day." Selected references and an index help to make this book a source of enlightenment for the management of the buffalo wolf ecosystem.

The book will appeal to a wide audience and is perhaps structured to do that. As a biologist I would have appreciated a little more development in some areas, perhaps at the expense of information about people. The differentiation of Plains and Wood bison was not sufficiently explained. There are some interesting aspects to discuss here (for more information on separating the two kinds of bison and other information, see Mitchell and Gates 2002). As another example, much more could have been said about the starlings observed perching on the bison in chapter 3. They are a reminder of the impact of humans, even in this remote wilderness. They spread from a flock introduced to New York City in 1890. At the time this may have been the furthest north that they had spread in Canada and clearly they were not confined to human habitations such as Fort Smith. This is additionally interesting because it is a reminder of another careless introduction which contributed later to the major bison controversy in Wood Buffalo Park. Although I would like to have seen more in some areas, the book is not without anecdotes including subjects such as pollination of waterlilies, history of bush pilots, change in traditional experience of nature by native people and movement distances of lynx. etc. It is probably a good thing that Carbyn is able to focus to the extent that he does because there is so much to say in the experience of nature in the Canadian north.

Like most dedicated biologists and teachers, Carbyn has taken a number of hard hits. One of these was when the CWS wolf study program was terminated. Of course many government programs are not based on long term visionary thinking, but I am not sure that I can accept Carbyn's view that this is usually a consequence of leaders lacking vision. Leaders are often just not strong enough to break away from the constraints of ignorance surrounding them. Without actually saying so, Lu Carbyn reminds us that independent and visionary thought as well as implementation of personal goals are characteristic of some people. Fortunately, these people help to compensate for the lack of long term visionary thinking elsewhere. Carbyn has a message for biologists. He describes how in field study, intuition and imagination play an important role. We are reminded to think like a scientist – but not to the exclusion of being a naturalist. He notes that "we should be taking from nature… a sense of what it is rather than its soul." The style of writing is personal and conversational with digressions and flashbacks. It is a very pleasant read.

This book promotes wilderness which is a part of Canadian heritage and identity and this alone makes it a valuable contribution. It also presents a fascinating biological and historical perspective on wolves and bison in Wood Buffalo Park. It introduces the world of a biologist. It will bring to many readers an understanding of the science, issues and politics of biology. Anyone can learn from it and enjoy it. By educating in numerous ways it will contribute to the protection of nature. It should be a source of pride for Canadian field biologists.

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Rutter, R. J., and **D. H. Pimlott.** 1968. The world of the wolf. J. B. Lippincott Company. New York. 202 pages.

Grassland Grouse and their Conservation

By Paul A. Johnsgard. 2002. Smithsonian Institution Press, Washington, D.C. Hardcover. 157 pages. $34.95 U.S.

When Paul Johnsgard perceived that most grassland races of grouse had decreased in numbers since he wrote *The Grouse of the World* in 1983, and that some were apparently doomed to follow the "Heath Hen" into extinction, he responded by writing yet another book. Johnsgard is well qualified for the task. He writes lyrically, draws exquisite sketches, and is cited in the *Seventh American Ornithologists' Union Check-List* as an authority on the taxonomy of the Greater and Lesser prairie-chicken.

The first chapter deals with the decline of the Heath Hen and its final extirpation on Martha's Vineyard, off the coast of Massachusetts. The remainder of the book provides us with a detailed account of recent population trends among the various races of grassland grouse, and provides current rough population estimates for each. Such detailed state-by-state accounts of declining ranges and populations for almost all races makes for depressing reading.

The Lesser Prairie-Chicken, whose closest ecological partners are Shinnery Oak and Sand Sage, is holding its own in one part of Kansas, but its range has decreased greatly in each of its five states. In New Mexico, the population has dropped from 40 000 to 1000; in Oklahoma, from 15 000 to less than 3000; in Colorado, numbers have dropped by about 97 per cent; in Texas it has dropped to about one-third of one per

cent of its historic numbers. In a few areas of contact with its larger relative, the Greater Prairie-Chicken, some hybridization occurs.

The Greater Prairie-Chicken vanished from Tennessee by 1850, Kentucky by 1874, Arkansas by 1913, Ohio by 1934, and Michigan by 1983. Hunting seasons were closed permanently in Missouri in 1907, Colorado in 1937, Minnesota in 1943, North Dakota in 1946, Wisconsin in 1956, and Oklahoma in 1998. The last known nesting in Iowa was in 1952, but after reintroduction attempts there are now 44 males on six booming grounds. In Kansas, Nebraska and South Dakota, populations remain large enough to permit an annual hunting season, but even in these three states the area occupied has decreased drastically.

The *attwateri* subspecies once may have numbered 100 000 birds when it occupied six million acres of Gulf Coast prairies, mainly in southeastern Texas. Now that predators take 53 per cent of nests, brood survival to eight weeks is 34 per cent, and adult annual survival rates vary from 11 to 36 per cent, the population has dropped to about 45 birds. This race appears to be doomed.

The Greater Sage-Grouse, specifically adapted to sagebrush, has dropped from a population of near 2 million in 1950 to about 200 000 in 2000, and it has been extirpated from Nebraska, Oklahoma, New Mexico, and Arizona. In the late 1970s it was still being shot by hunters at the rate of 83 000 per year in Wyoming alone. In Saskatchewan, the population dropped by up to 92 per cent between 1970 and 2000.

In 2000, when the Gunnison Sage-Grouse was named a new species, *Centrocercus minimus*, it occupied only a small portion of its former range in southwest Colorado and adjacent Utah. Fewer than 5000 adults remained. Johnsgard notes that this new species, due to the "glacial rate of movement of the federal legal process ... might well be endangered before [it is] officially recognized as threatened, and extinct before [it is] classified as endangered."

Finally, two of the three grassland subspecies of the Sharp-tailed Grouse have shown drastic decreases in range, including a loss of 90% of the range of *T. p. campestris* in Wisconsin and Michigan and 60% in Minnesota, even though their habitat has changed less than that of any other grassland grouse species. In the far west, an even more drastic loss of range (92%) has occurred for *T. p. columbianus*. Since 1998 it has been listed as threatened in the state of Washington; satisfactory populations survive only in British Columbia.

The greatest strength of this book is the detailed maps of past and current ranges of each race. Descriptions of the mating rituals of each race are especially well done. I have minor criticisms. Coverage is less detailed for all grassland grouse in the Canadian provinces; Johnsgard fails to state conclusively that the Greater Prairie-Chicken is officially considered to be extirpated from Canada, and that the recovery team for this species was disbanded in 1994. It is not true that hybridization between Greater Sage-Grouse and Sharp-tailed Grouse occurs only in eastern Montana and eastern Wyoming; it has also been reported from extreme southern Saskatchewan. The disruptive effect of Ring-necked Pheasant cocks at Greater Prairie-Chicken leks is barely mentioned.

The final chapter asks, "Can the fabric be mended?" For some races of grassland grouse, the Greater Sage-Grouse in Canada, the Lesser Prairie-Chicken and the *attwateri* race of the Greater Prairie-Chicken in the United States, it may already be too late. "As agriculture became more mechanized and the farms larger, fewer and fewer acres were spared from increasingly effective pesticides and herbicides ... the prairie grouse began a long, slow, but certain descent into oblivion."

No one knows what the future holds, but Johnsgard certainly has raised the alarm call.

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Crows: Encounters with the Wise Guys

By Candace Savage. 2005. Greystone Books #201-2323 Quebec Street, Vancouver, British Columbia V5T 4S7 Canada. 113 pages. $27 Cloth.

Several years ago I overheard a person say "He must have been slow to volunteer. He's got stuck with crows." They were talking about me. I had actually been one of the first to volunteer to write sections of the original Ontario breeding bird atlas and I had deliberately asked for crows as my assignment. Why do people think of these birds as common, black and noisy, and therefore dull?

I have always found crows to be entertaining, clever and well worth watching. It is comforting to know there is at least one person who shares my enthusiasm for these wonderful birds. Candace Savage has collected tales and myths about the crows of our world. For the crow fan this is delightful reading. For the crow-deficient minds of others this book will offer enlightenment.

The author has sifted though both archaic stories and modern research on the black crows (the gaudy jays do not get mentioned). She covers the biology, social structure and interactions, communications and tool-use to try and answer the key question. Are crows intelligent? Crows have been observed by many of us doing things that suggest they have mentally resolved a problem. The difficulty is their behaviour can be explained in other ways. The research that Savage

references is generally aimed at giving a crow a test that should prove or disprove intelligence. This is an elusive goal and I am not convinced that crow intelligence is proven. However, the results are so amazing that it is impossible to deny that crows behave intelligently. In some ways they are surprisingly similar to humans.

This is an ideal gift book. It is fun to get and read, but not the sort of book you normally buy for yourself.

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Antipredator Defenses in Birds and Mammals

By Tim Caro. 2005. The University of Chicago Press, Chicago 60637. xv + 591 pages. U.S. $95.00 Cloth. $38.00 Paper.

Recently I read a report of Merlins hunting migrant chickadees as they flew out from a point along Lake Ontario. The falcons were capturing and eating the chickadees on the wing, and it made me ponder how defenseless the birds seemed, and the contrast with the shorebirds that Merlins are normally hunting in this location. To those of us who watch birds such events can often seem exciting and dramatic interludes in the birds' more usual activities, such as feeding. As such, they have generated over the years a host of anecdotal notes of the type above. But of course, defenses against predators are absolutely basic to an animal's life: without them there would be no feeding, or anything else. So the challenges of avoiding predation have become a fertile field of investigation.

Which brings me, finally, to this book, in which Tim Caro examines the bewildering range of mechanisms and strategies that enable mammals and birds to evade capture and death from the wide variety of predators that most animals face. Such is the multiplicity of all of these – prey species, defenses and predators – that any synthesis is daunting, yet Caro does a masterly job of mustering the relevant data from a huge and growing field, and rendering it into a coherent and lucid whole. The 87 pages of references alone attest to the encyclopedic character of the undertaking.

The book is divided into 13 chapters, with the first devoted largely to setting the stage, followed by 11 that trace the "predatory sequence" from traits that avoid detection, such as cryptic coloration, and behavioral mechanisms to avoid detection, through vigilance and prey signaling [both warning and of unprofitability], the benefits of grouping, and then physiological and morphological defenses, such as body size, quills, spines, antlers and the like. There is a chapter on nest defense, and one on mobbing and other group defenses, with chapter 12 devoted to "behaviors of last resort". Taken together, these provide a comprehensive overview of predator avoidance, with copious references to the literature, and tables and figures from relevant papers providing a useful complement to the text. Caro's formidable command of his subject is apparent throughout.

The thing that impressed me most about the book is its clarity. As a generalist with no more than a broad interest in the field, I had some trepidation about undertaking this review. The subject is, after all, at this level a technical one, and technical treatises can be relatively incomprehensible to the non-specialist. I need not have worried. While hardly light bedside reading, the entire text has a refreshing clarity and readability. From the preface onwards Caro clearly states what he is going to do, with the reasons why, and provides the appropriate references to those allied aspects of the field that he chooses not to cover. Then in each chapter he again defines the area he will cover, discusses it critically with copious examples, noting the weaknesses in our current understandings, and then provides a concise summary at the end.

Chapter 13, framing questions about antipredator defenses, brings the disparate threads of the previous chapters together, and focuses in on ten "pressing questions" which the author sees as particularly important at this time.

An appendix gives the scientific names of vertebrates mentioned, and each chapter has a delightful sketch of some aspect of animal behaviour that is appropriate to the text that follows. All the references that I checked were accurate, and the book is agreeably free of typographical mistakes. I am less enthusiastic about the indices, which are divided into "prey species index" and "subject index", and the former is further subdivided within the index itself. I've never been able to comprehend the rationale for split indices, but these seem adequate, if irritating.

This book is a major contribution to the literature on this subject. It is a "must" for anyone working in this or allied fields, an important reference text, and a comprehensive, stimulating and thought-provoking synthesis of a very important area of animal behaviour.

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For Love of Insects

By Thomas Eisner. 2003. The Belknap Press of Harvard University Press. Cambridge, Massachusetts. 448 pages. Paper.

I remember well being almost overcome with wafts of formic acid after breaking apart an old black spruce stump during a stroll in the forests of eastern Newfoundland. At the time I figured that I was the victim of an ant species of the subfamily Formicinae, ants that Eisner describes as "spray gun(s) on legs." Such ants, each containing a formic acid gland, can eject a fluid that may exceed 50 percent formic acid. Put hundreds of such ants together in one spruce stump and the chemical barrage can be overwhelming.

A self-described "incorrigible entomophile," Thomas Eisner, Schurman Professor of Chemical Ecology at Cornell University, has written a feast of a book. In astonishing detail and delight, he describes a host of insects and arthropods and the myriad ways in which different species have evolved sophisticated chemically-based means of predation, protection, mating, and a host of other interactions among insects or between insects and plants.

Eisner's early passion for the natural history of insects combined with his interest in natural chemistry led to his pioneering advances in the chemical ecology of insects and arthropods. Chemical ecology came to be his life-long passion as he delved into the secret lives of insects mediated by a host of chemical signals. The beginnings of potential research projects were often formulated during his favourite walks in nature, particularly in the southern and southwestern United States. These initial observations often led to further sophisticated chemical studies on the identity and mechanism of the chemical basis of insect behaviour.

The book is a feast of stories about insects and their wonderfully adaptive chemicals that allow them to live and survive what is obviously a precarious existence. Each story is adorned with fascinating photos (many from the adept hands of Eisner himself) of a world seldom seen or appreciated by most of us.

These stories of insects and their chemical ecology are wonders and gems in themselves. Of equal or even greater delight, is the sense of wonder and love communicated by Eisner throughout the book's pages. By self admission, the study of nature for this naturalist explorer can never disappoint him. His passion is infectious. His stories are peppered with the joy and exhilaration of research and discovery. The reader is introduced not simply to facts and explanations, but to a host of graduate students, post-docs, and collaborators, including his wife Maria, who shared the joy and delight of Eisner in his "love of insects."

Eisner ends his work by noting that without curiosity, without passion for discovery, nature cannot endure. He laments our steady encroachment upon nature, upon the loss of boundaries. He notes, however, that ultimately, curiosity will be sustained – and that we will coexist with the living world. Can love of insects make a difference Eisner wonders? He ends this treasure of a book by admitting that he would like to believe that it does. I could not agree more.

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Rare Bird: Pursuing the Mystery of the Marbled Murrelet

By Maria Mudd-Ruth, 2005. Holtzbrinck Publishers, 175 Fifth Avenue, New York, New York 10010. 298 pages. US$16.29.

This well-written environmental history book captures a fascinating story: the Marbled Murrelet, a seabird nesting mostly in trees: one of the greatest environmental failures in the conservation history of globalization, western civilization and North American governmental stewardship. The book states that since 1830 due to logging of the old-growth forest unsustainable activities in the Pacific Northwest has spared only 10% of the historic nesting habitat of the Marbled Murrelet. Other well-documented threats for Marbled Murrelets in this book, are fisheries (gill net by-catch) and oil pollution. That this species is covered by the U.S. Endangered Species Act (ESA) is a controversial topic because, in areas around Seattle and north of it, it is among the most abundant birds almost year round.

The book reads well and can be recommended to naturalists, arm-chair explorers as well as to conservationists, ornithologists, Marbled Murrelet activists, and researchers. Its great strength is its documentation of the recent history of Marbled Murrelet research in the United States, in California, Oregon and Washington. Also, an archeological and native view from the Haida and Tlingit tribes is presented, including fascinating stories about specimen and egg collections now distributed world-wide (e.g. in museums of London and Vienna). Accounts of famous explorers and early naturalists in "Marbled Murrelet land" such as Latham, Gmelin, Banks, Pennant, Lever, Cantwell, Dowell and Jewett are included as well.

The text reads like a detective story: The toenail of the Marbled Murrelet is as well covered as the first official nest found in 1974 near San Francisco by H. Foster. Other fascinating details cover a Canadian nest encountered 1953 by W. Feger, how S. Sealy initiated the first Marbled Murrelet studies in North America, and Russian scientist S. Kishchinskii's theory of juveniles leaving the nest to the remote ocean by simply following a stream. Insights are provided on how the International Council for Bird Preservation accepted Marbled Murrelets as a conservation issue of global

importance. And the reader will enjoy to learn why Ridgway's colour code matters for Marbled Murrelets, why K. Nelson converted from studying woodpeckers to Marbeled Murrelets, about T. Hamer's infamous eggshell surveys, and the pioneering work by S. Sealy's student H. Carter. But it also deals with a heroic description of the many unfunded Marbled Murrelet pioneers that went to promote science in the public conservation battle, or simply to advance ornithological knowledge. The book makes clear that one nesting tree alone can fetch $100 000, resulting in huge sums being at stake when many hectares of forest are up for public discussion for potential logging. These high values explain the subsidized heli-logging of Marbled Murrelet habitat on steep slopes at high elevations.

The book handles the conservation failures for the Marbled Murrelet well, specifically the ones from the many governmental agencies involved (the reason why this book had to be written in the first place). Author Mudd-Ruth presents these shortcomings with great skill, such as the early failures of the U.S. Fish and Wildlife Service (did not carry out surveys) and U.S. Forest Service (ignored habitat inventories). But besides the notorious Bureau of Land Management and even the National Park Service, one could easily extend these shortcomings to the suite of state agencies such as Departments of Game, Natural Resources, Parks and Recreation, and certainly Forestry. And since oceans are directly involved in this topic, the National Institute of Marine Fisheries, the National Oceanic and Atmospheric Administration, the National Sanctuaries and the U.S. Navy all get to carry the blame as well. The Canadian side involves at least the Canadian Wildlife Service, the Department of Fisheries and Oceans, the British Columbia Ministries of Forestry and Environment, Parks Canada, and the Mineral Management Service. The Marbled Murrelet swims with steadily declining numbers in all of these "governmental waters", as well as in the industrial and private ones. And almost all of these agencies have a noted Marbled Murrelet conservation history, and some, to this very day, are doing nothing of relevance to resolve the Marbled Murrelet problem.

It becomes clear from this book that these institutions do not provide relevant public guidance and high quality data for sustainable decision-making, and addressing the inherent conflict between endangered species, economic growth and development. Are the existing administrative structures and the reward and promotion systems for the staff of these agencies really able to manage such problems at all?

The author mentions a lot the Pacific Seabird Group (PSG), which is involved as a lobby and expert group for Marbled Murrelets. However, the PSG is not a legal governmental body and can only compile and provide suggestions. To this very day we have no high quality old-growth inventory layer relevant to Marbled Murrelet habitat and sustainable management of the precious forest; nor do we even have any relevant studies and data collected throughout its range on the food items of Marbled Murrelets; e.g., Sand Lance. As this powerful book outlines, the Pacific Northwest Forest plan created 1994 by the Clinton administration has improved the Marbled Murrelet management at least for the states of the lower 48.

The book makes the tensions around the Marbled Murrelet situation explicitly clear: In 1989 the Marbled Murrelet was suggested as a candidate species for the ESA. However, it took three more years. When the Audubon Society of Portland sued the U.S. Fish and Wildlife Service the bird eventually received a status in 1992 federally listed as a threatened species; when it was the recovery process could start. The status review of this endangered species is due every five years, but as the reader will learn, it has been delayed from 1997 til 2002 when eventually a timber industry group took the government to court. Another classic "MaMu" legal case is presented with the influential court case from 1993 "Marbled Murrelet vs. Pacific Northwest" where EPIC (Environmental Protection Information Center) sued Pacific Lumber.

Further, as well-presented in this book, Marbled Murrelets live in a complex habitat; e.g., where one of the biggest marihuana grower industries in the western world makes its (illegal) living. Raven populations in the Pacific Northwest have increased 15-fold: a human subsidized Marbled Murrelet nest predator. Habitat fragmentation is severe, and the outlook is very bleak, as the loss of Redwoods shows for instance.

This book could have been improved if the Russian and Canadian populations were explained and elaborated on in more detail: their story is as exciting and as full of tensions as the U.S. one and inclusion would provide a complete context. Most relevant Canadian researchers and very influential players are not named and elaborated on in this book, such as I. Manly, V. Bahn, G. Kaiser, A. Derocher, F. Cooke, A. Burger. This book also has no maps (but nice black and white figures by Paul Jones). It was the Canadians who solved one of the biggest technical problem in the study of this bird: being able to catch it. The brood patch story presented in this book was already revised when this book was written and by Canadian researchers who the author quotes. The Canadian Clayoquot Sound (just north of Seattle), the location of a major environmental conflict and Canada's largest mass-arrest in history, is hardly mentioned at all.

The book explains that more than 3000 trees have been climbed in order to find the elusive nests, but less than 61 known nests are reported in this book (likely, one has climbed trees and searched in the wrong field sites and habitats). This leads me to a more serious flaw in this book. The author chose to ignore the known nests and findings; e.g., as presented at PSG meetings at which the author personally was present and referred to and cites in the text. Marbled Murrelet nests are actually located across elevations and on steep slopes, which will modify the conservation pressure on habi-

tats. The reader is advised to adjust the nest site image presented in this book at the following website by the Center for Wildlife Ecology http://www.sfu.ca/biology/wildberg/mamuweb/welcome.htm where over 120 nests are presented to the public.

Unfortunately, this book does not document that "low elevations" alone does not sufficiently describe the nesting habitat. It does not deal with how the myth of low elevation old-growth forest evolved in the first place, and why this myth remains active within the conservation community to this very day. The book reports an uncommented figure for 10s of millions of Marbled Murrelets in Alaska alone; this must be way too high by the factor 10.

No doubt, the peculiar efforts by the current U.S. government administration trying to de-list this species from the ESA and against all efforts of most biologists will keep this well written and very readable book in high demand. It's the first of its kind for the Marbled Murrelet, and a great description for the state-of-the-art of the environment and conservation in arguably one of the most powerful countries in the world.

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BOTANY

Canada's Forests: A History

By Ken Drushka. 2003. Forest History Society Issues Series. McGill-Queen's University Press, Montreal and Kingston. 97 pages. Paperback. $12.95 Can.

This treatise was written by a journalist, now deceased, who had considerable practical experience in the forest industry, having worked as a logger in British Columbia. It is highly readable, being targetted at the nonspecialist, with few references or supporting data. Even so, it provides considerable food for thought in a compact format. The treatise presents a generally positive picture of Canadian forests and the forest industry. Ken Drushka states his premises boldly: "Canadian forests still exist virtually intact. Since European colonization ... only about 6 percent of Canada's forest land has been converted to other uses" (page vii). Moreover, "it is inaccurate and misleading to claim that the country's forests are in the process of being destroyed, devastated, decimated, or damaged beyond recovery" (page 82). On the contrary, Drushka considers that, by and large, "they are whole and healthy" (page 82). This is certainly a view markedly at variance with that usually presented through the popular media.

Drushka develops his views in five chapters, focussing on "The Canadian Forest", "Early Forest Use", "Industrialization of the Forests", "The Rise of Forest Conservation", and "Sustainable Forest Management", which includes a brief survey of the state of Canada's forests as of year 2000. The survey covers a lot of ground (pun intended!) and, as might be expected, the treatment of topics is somewhat uneven and often cursory. I found the summary of the postglacial assembly of "The Canadian Forest" especially unsatisfactory. Also in this opening chapter, Drushka sets the scene by identifying and describing eleven modern forest regions across Canada, although only ten are shown on the accompanying map. Following this introduction, his historical survey in the next four chapters is basically chronological and sequential.

Drushka notes that the Canadian landscape has been home to people throughout postglacial time and that Aboriginal people "had an often-significant impact on the forests" (page 17). He points out that Aboriginal people used fire as a land management tool. I found it refreshing to see an environmental history which acknowledges that Canada had a human history before European settlement. Drushka identifies the first major impetus for sustained forest use as the establishment of the fishing industry in Newfoundland in the 1500s. Interestingly, he does not highlight the fur trade as a major reason for forest clearance, pointing out that permanent settlement by Europeans was actively discouraged by the trading companies. He sees the main phase of European settlement, beginning in the seventeenth century, being associated with "serious and mostly negative impacts on the forests" (page 23), as land was cleared for agriculture and wood was used as the principal fuel for winter heating. Commercial exploitation of the forests began in the late seventeenth century, propelled by warfare and conflicts that stimulated Britain particularly to turn to Canada as a source of supply for timber. The exploitation front moved westward and inland from the east coast to interior Canada, primarily along the major waterways, following a similar pattern to settlement. Drushka traces the establishment of administrative policies that made the forestry industry a major source of government revenue, especially later at the provincial level.

In the third chapter, Drushka examines more closely the industrialization of the forest industry through the latter part of the nineteenth century. He considers that the spread of transportation networks, especially the railway, had a triple effect on the forest industry. First, railway construction consumed large amounts of timber. Second, better transport networks encouraged the spread of lumbering to previously economically inaccessible regions. Third, the wood-burning steam locomotives themselves demanded large quantities of timber as fuel. Clear-cutting became common. Drushka points out that the spread of lumbering went hand-in-hand with devastating wildfires that spread through the remaining slash on clear-cuts, often start-

ed by sparks from various industrial machinery. Drushka notes a prevailing lack of concern with the reduction in area of forest: "Well into the twentieth century the sentiment was still widespread that forests were an impediment to development and settlement, and their eradication was acceptable, if not desirable" (page 37). Nevertheless, by turn of the twentieth century, the reduction in forest land had become so marked that it was starting to raise alarm in some quarters, especially in government circles. This awareness marks the beginning of the rise of the forest conservation movement.

This movement sprang from "a desire to maintain forests in perpetuity" (page 61) and was part of a broader conservationist movement, driven by social and ideological trends. Drushka traces the practical application of forest conservation to the establishment of forestry schools at universities and founding of various forest societies. The overall result was the "professionalisation" of forestry and the development of a cadre of scientifically-trained foresters. Canadian forest conservation policies therefore were rooted in a belief that management had to be science-based and, as far as possible, separate from the political process. Drushka points out that in Canada forest conservation was essentially utilitarian and not preservationist, underpinned by the belief that the forests were there to be used, albeit within limits. Hence, throughout various legislative and regulatory initiatives has run the idea of "sustainable yield". However, Drushka argues that all these policy approaches since the Second World War have focussed on sustainable yield of timber only, while other valuable and sustainable aspects of forest lands, such as water quality and biodiversity, have not been included. The conclusion is that an overall comprehensive approach was lacking, which set the stage for the conflicts of the last few decades.

In the last chapter, Drushka examines forest management in the closing decades of the twentieth century. This was a time of considerable conflict and rethinking. It had become apparent that previous estimates of "sustainable yield" were not in fact sustainable, partly because replanting was not keeping up with extraction, partly because of variations in growth, and partly because forest inventories were not in place to allow for a realistic assessment of what was "sustainable". Yet the forest industry was trying to respond to increasing demand for forest-based products, such as pulp and paper. At the same time, there were increasing demands being placed on forests from other users, including recreationalists and environmentalists, who placed different values on the land. As Drushka notes, clashes between various groups of users were becoming more common. In this context, I think many readers from western Canada will remember the blockades of logging roads and protesters being removed by police. Although Drushka mentions competing uses, he does not examine any in detail, and this superficial treatment might leave some readers wondering why these conflicts were so bitter. Drushka does indicate, however, that these clashes were highlighting incompatibilities between uses and leading to greater polarisation. Increasingly powerful, vocal, and articulate interest groups were lobbying for a preservationist approach to forest lands, partly through advocacy for the establishment of parks and other types of protected areas where the forest industry would be excluded.

The result, concludes Drushka, was that forest management and planning could no longer be the purview just of provincial forest services. The process had to be opened up. Drushka identifies a new approach to management, especially through the 1990s, called "holistic" forestry or "sustainable forest management", which involves "a broadening of the concept of sustained yield to include all components of a forest" (page 69). He sees this change in philosophy as an impetus for the development of the Canada Forest Accord (1998), which acknowledges that forest ecosystems should be managed to benefit a broad spectrum of users. One of the more interesting outcomes of this shift in perspective has been the development of various certification programs. Drushka observes that such programs provide an incentive for forest companies to practice good management. Nevertheless, as Drushka's survey shows, sustainable forest management is clearly more demanding than the old style "cut and move on" approach, requiring greater flexibility and adaptability on the part of the forest industry and a recognition that, no matter how vast they may seem, the forest lands are a finite resource.

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ENVIRONMENT

The Natural History of Bermuda

By Martin L. H. Thomas, First Edition, 2004. Bermuda Zoological Society, P.O. Box FL145, Flatts, FL BX, Bermuda.

Islands are the Rosetta stones of evolution. They also contain some of the most vulnerable natural habitats on the planet and many species at risk. These two factors make them of great interest to naturalists and ecologists. These themes are explored in intimate detail in *The Natural History of Bermuda*.

Bermuda is an archipelago of over 100 islands in the mid-Atlantic due south of Nova Scotia and 965 kilometers east of Cape Hatteras. Having a surface area

of only 55 square kilometers, no place in Bermuda is more than a kilometer from the ocean. It has a sub tropical climate due to its situation in the Gulf stream, and a fascinating geological history. Some 100 000 years old, Bermuda is a seamount with a limestone cap and red soil layers originating from sand blown from as far away as the Gobi Desert. It has a classic karst landscape perforated by caves and sink holes.

With 63 000 inhabitants it counts as one of the most densely populated places on earth, much exacerbated by an annual influx of 600 000 tourists attracted by its picture post card beauty. Humans have been coming to Bermuda since the 1500s when it was first sighted by Europeans, with permanent settlement dating from the 1600s. The island's terrestrial habitats were quickly transformed; originally covered by forest these were sadly depleted by ship building and other industries and today one finds only tiny remnants. The original inhabitants included a flightless rail and a "crow" rapidly exterminated by the new arrivals. In the author's words, "we may never know what delicate animals and plants were eradicated."

The author repeatedly returns to this theme, describing how humans have, intentionally or not, altered the Island's ecology. Boars, introduced by sailors prior to permanent settlement undoubtedly finished off the flightless rail and other vulnerable fauna. Two other examples tell the tale: Yellow-crowned Night Herons were successfully reintroduced to control an accidently introduced land crab which had the bad manners to dig golf ball sized holes in golf courses, making a "hole in one a certainty". Less successfully, anoles were introduced to control an accidently introduced, destructive fruit fly but ended up eating ladybugs which had in turn been introduced to control an accidently introduced scale decimating native trees. Great Kiskadees, introduced to control the anoles, ended up eating the endangered Bermuda skinks. And so it goes.

Like all remote oceanic islands, Bermuda has a limited terrestrial biodiversity, consisting mainly of species that can be transported over long distances by the wind or ocean currents. This paucity is illustrated by the contrast between the number of native vascular plants, 156, and the number of marine fish, 423. Native inhabitants include birds, insects and plants originating from North America and the Caribbean: the marine life is distinctly Caribbean, sharing many of the same colourful reef species. Some of the arrivals have diverged sufficiently from their ancestors to become endemic species or subspecies, for example the Bermuda Skink is thought to have evolved from a shared ancestor with the North American Five-lined Skink. Perhaps the most celebrated member of the Bermudian assemblage is the Cahow, or Bermuda Petrel; originally known only from fossils it was famously rediscovered in 1951 when a scant few pairs were found breeding.

All of this is set out by the author in 21 twenty chapters variously focused on key environments (reefs are the largest ecosystem, fresh water ecosystems the smallest) or groups of animals. The book is extensively illustrated with colour photographs but avoids being a "coffee table" book by the detailed narrative which introduces the reader to each theme and describes the key inhabitants and processes involved. Attractive maps are found on the front and end pieces. Occasionally the text reads like a catalog, but there is enough analysis and sufficient interesting observations that the reader's interest should be rekindled. It also reads from time to time like a university lecture, which is not surprising given that the author is a university lecturer. Because each chapter is rather self standing there is a fair amount of irritating repetition which could have been reduced through a final editing session. A few proofing errors are present such as mention of the "Blade-headed Gull", surely a cut above the usual lariid, and the geographically confused Antiguan Anole which apparently hails from Barbados as opposed to the Barbadian Anole transported from Antigua. While most groups are well covered, marine mollusks and sea shells receive scant attention which is curious given the level of interest these attract.

The final chapter looks to the future. Exports of the valuable endemic Bermuda Cedar were banned as early as 1657, however, systematic conservation measures only emerged much more recently. Marine ecosystems are relatively well protected, however, only 7% of the land surface receives official protection. A protected species act was introduced in 2003 and there are prohibitions on the importation of new species. Environmental education, particularly of youth, is a key priority and it is to be hoped that this handsome book will help especially as it is accompanied by a CD, making it an "electronic book." If you have an interest in island biogeography, or just want to dream about your next escape from a Canadian winter, this book will be of interest.

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Saskatchewan Uncommon Views

By John Conway. 2005. The University of Alberta Press, Edmonton. 135 pages. Illustrated. $29.95.

The results of John Conway's photographic forays across Saskatchewan are certainly "uncommon". Sometimes strikingly beautiful, always minimalist, his photographs elicit reflection, nostalgia, even humour. While this is not a book on natural history, it will appeal to many readers, especially to serious practitioners of photography and to residents of Saskatchewan steeped in its history and geography. Superficially, the photographs confirm the popular belief that Saskatchewan is flat, dull and colorless. But a closer

scrutiny (St Denis hills, for example page 43, or cattle and hay bales in a snowy landscape, page 5) suggests the beauty he could have depicted had that been his primary intention. In addition to the photos, the book contains three thoughtful essays by well known Saskatchewan writers: Sharon Butala, Helen Marzolf and David Carpenter. A careful reading of these essays is likely to result in a deeper appreciation and understanding of Conway's art and sensibility.

Essentially, Conway shows what the prairie once was and what has since happened to it and to the dreams of thousands of farm families who immigrated to the West in the first decades of the twentieth century. His photos suggest a variety of reactions to a land that can be both inviting and cruel. Small towns are disappearing; many farm homes sit forlorn and abandoned; the larger urban centres reflect a new way of life, essentially industrial and commercial, isolated from the land which nurtured aboriginals and early settlers. However, several of his pictures reveal the tenacity and spirit of the people still living in rural Saskatchewan: the remains of a bicycle mounted on a fencepost in imitation of modern art (page 13); a roadside sign: Shirl's Upholstery, standing in heavy grass. Conway's caption: "Shirl has done upholstery out of a mobile home for twenty five years."

A handsome book, reasonably priced, *Saskatchewan Uncommon Views* is a significant achievement, particularly fitting since it appeared in the province's centennial year.

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MISCELLANEOUS

Manly Hardy (1832-1910): The Life and Writing of a Maine Fur-buyer, Hunter, and Naturalist

By William B. Krohn. 2005. Maine Folklife Center, 5773 South Stevens Hall, University of Maine, Orono, Maine, USA 04469. 343 pages. $24.95 hardcover, $19.95 paper.

Manly Hardy documented more about Maine's wildlife during the last half of the 19th century than any other writer. He was "a keen and reliable observer ... a faithful recorder," and a "widely capable, fiercely independent, highly intelligent and positive man." Krohn demonstrates "just how dynamic Maine's natural environments were during much of the nineteenth century." This book was possible because the author had access to the documents collected by two unrelated people: Fannie Hardy Eckstorm, Hardy's first child, and the late Dr. Ralph S. Palmer. In addition, Palmer was responsible for much of the annotated bibliography which appears at the end of the book.

The first 78 pages, written by W. B. Krohn, deal with Manly Hardy's life. Hardy was a complex person with many seemingly contradictory qualities. A small and sickly child in the small town of Brewer, Maine, he became religious as an adolescent, and studied Greek and Latin in a private school taught by a minister. In his twenties he became a hunter and trapper who regularly took life for food and fur, yet he loved pets and could be sentimental about animals. When Hardy was 32, he inherited from his father the family fur business; he handled over half a million dollars worth of furs during his career, the largest fur business east of the Rocky Mountains.

When Hardy was growing up, Indians outnumbered white people in Brewer. Hardy's approach was unusually enlightened for his time; hunting and traveling with them, he learned their ways. He respected their knowledge and skills. They confided in him and he guarded their secrets.

Krohn deals mainly with Hardy's interests outside of his business. Hardy amassed a collection of over 3000 birds; he traded Passenger Pigeons from Maine to obtain some of the specimens. He wrote at least 150 articles about nature, over half of which appeared in *Forest and Stream*. Ernest Thompson Seton (some of whose delightful sketches are reproduced in this book) considered Hardy's writings to be among the most useful information in print; he quoted Hardy 72 times in his monumental, four-volume *Lives of Game Animals* (1925-1928). Ralph S. Palmer cited Hardy 21 times in *Maine Birds* (1949).

The main portion of the book, 203 pages, reproduces some of Hardy's most interesting articles, including two accounts of long winter trips in the Maine woods. The mammal articles selected by Krohn concern four species that are now extinct or nearly so in Maine, the woodland caribou, wolf, cougar and sea mink, plus others of special interest, the lynx, bobcat, fisher, moose, beaver, river otter, and porpoise. Hardy's well-written accounts are still of interest today, offering the best available comparison with what things were like more than a century ago. The final 32 pages give an annotated bibliography of Hardy's other bird and mammal vignettes. I found only one minor error, made by Hardy, who misspelled the surname of Roderick Ross MacFarlane [not MacFarland].

For those with an interest in the history of fur-bearing mammals in the days when Maine's woods were in a pristine state, this book is a treasure. It will be of nearly equal interest to residents of adjacent New Brunswick.

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Audubon in Edinburgh and his Scottish Associates

By John Chalmers. National Museums of Scotland, Edinburgh. 2002. 157 pages. $34.95 U.S. $70.00 Can. Available from Codasat Canada Ltd., #1, 4335 West 10th Ave., Vancouver, British Columbia V6R 2H6 Canada.

John Chalmers, an orthopedic surgeon in Edinburgh, has filled a void with his careful documentation of archival letters and files dating back more than a century and a half. Although most members of the general public know the name of Audubon, few historically-minded ornithologists realize that Edinburgh, Scotland, was Audubon's favourite among all the world's cities. Audubon had received little encouragement in America, or in London or Paris, but Edinburgh grew to love him during the 22 months he spent there during his six visits, two of which lasted for six months each. Audubon's fame and his success date from these six visits. Chalmers includes twelve pages of biographical profiles of men who interacted with Audubon.

Audubon, the rough but charming and talented backwoodsman, was unexpectedly well received by eminent people in what was then the world's leading city for science endeavours. Members of the intelligentsia wined and dined him. The august Wernerian Society welcomed him. Thirteen of Audubon's early scientific papers were published by four different Edinburgh scientific journals. William McGillivray, in particular, went out of his way to help him with the scientific aspects of ornithology. The kindness of such savants never ceased to amaze Audubon.

Audubon's *Birds of America* was extremely expensive to produce. The first 10 plates were engraved by W. H. Lizars in Edinburgh, though publication later switched to London. In total, there were 87 parts, which sold at two guineas each, for a total cost of £187, containing 435 plates and text. Chalmers provides a list of the present whereabouts of the 23 sets that were sold in Scotland, as well as a list of exactly fifty places, including 43 private residences, frequented by Audubon; all but 11 of these buildings are still standing.

Ironically, not one of the 14 complete sets of *Birds of America* sold in Edinburgh has remained there; the cash-strapped University of Edinburgh sold its set at auction in New York in 1992 for $4.1 million. There is an extant copy in Paisley, coincidentally the hometown from which Alexander Wilson had left in disgrace for America in 1794.

This book combines an informative text, helpful footnotes, and magnificent illustrations, including reproductions of some of Audubon's finest bird paintings. Readers will marvel, as Audubon did, at the extent to which Edinburgh launched his career. Among innumerable pleasures are the spontaneity and charm of Audubon's letters to his wife, back in America.

I detected few errors. Although Chalmers is correct in saying that Alexander Wilson, a transplanted Scot in America, named the Eskimo Curlew in honour of Audubon in 1813, he fails to appreciate that J. R. Forster in 1772 had pre-empted Wilson by naming the species from a specimen collected by Humphrey Marten at Albany, on Hudson Bay, in 1771. Elliot Coues is misspelled Cowes. The index is sadly incomplete, hardly excusable now that indexes can be compiled unerringly and almost automatically by highlighting each name in the text.

This sumptuous, 228-page, beautifully-illustrated, sturdily-bound paperback is necessarily expensive. It would be an elegant gift for anyone interested in Audubon, the primacy of Edinburgh during Scottish enlightenment, or the history of ornithology. One hopes it can be purchased by every major library in North America and Europe.

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A History of Devonshire Ornithology

By David G. Jenks. Isabelline Books, 2 Highbury House, 8 Woodlane Crescent, Falmouth TR11 4QS, Cornwall; e-mail: mikann@beakbook.demon.co.uk. FAX 0870 051-6387. 2004. Hardcover. 477 pages. £53 plus postage.

Devon is one of the most beautiful and interesting of the many British counties. David Jenks planned to write its ornithological history as a chapter for *Birds of Devon*, but when that project fell through he completed an entire book on the history alone. And what a book! Full of detail, printed on high quality paper, it is a sumptuous book, but almost too heavy to hold for someone who reads a chapter each night at bedtime.

As the Foreword explains (page xi), thoroughly-researched historical accounts such as this help us "understand the origins and raison d'être of the modern nature conservation movement." The first chapter deals with the prehistoric record – skeletal remains of birds found in seven different caves or deposits. These caves are mapped, but readers are handicapped by the lack of a map of Devon showing the many other place names mentioned.

North Americans can only envy the additional centuries of scattered historical information available in England. The Isle of Lundy, off the north shore of Devon, features prominently throughout. The first Lundy entry concerns the gannet colony and nesting peregrines found there in 1274 AD.

There is a sordid side to most of the accounts before 1900. So-called scientific interests were served by shooting a bird, then almost the only way to identify it. Physicians and country vicars alone seemed to have "the leisure, the academic training and the opportunity

to become well-informed naturalists" (page 135). More often than not it was the local minister of the Church of England who was guilty of massive slaughter of almost anything that flew. Jenks tells of the zealous collector who, while walking without a gun, saw an unfamiliar bird, knocked on the door of the nearest cottage, borrowed a gun from the stranger, and shot what proved to be a beautiful Night Heron in full breeding plumage.

Then there was the mercenary side of bird-killing. Village markets throughout Britain were replete with waders, marsh birds, even song birds, all of them to be purchased for the table. They fetched a surprisingly high price.

Quite apart from culinary sales, both birdskins and eggs were also available. Those interested in the distribution of bird species were apt to go to their local market and purchase the rare birds available for sale. In 1878 a Gyrfalcon skin sold for 50 shillings and a Golden Eagle egg for 25 shillings; a Passenger Pigeon skin cost only 6 shillings. As evidence of the extent of this trade, the relatively small town of Barnstaple supported two full-time bird-stuffers.

We can learn from some of the mistakes made in Devon. Many specimen records were made worthless by inadequate preservation, missing date and locality labels, and some were unknowingly brought by ship from offshore.

Throughout the book there is evidence of friction between those who collected birds' eggs and study skins and those who used the new field glasses to observe birds in the wild. The latter slowly and gradually came into the ascendancy after 1900.

We meet many interesting men, but I will mention only two. Colonel George Montagu, who wrote his landmark *Ornithological Dictionary* in 1802, was Devon's first important ornithologist; he sorted out the differences between the Montagu Harrier and the Hen Harrier, thus having his surname applied to the former. The first imperfect beginnings of a book to be devoted entirely to Devonshire birds was written by Andrew Tucker in 1809; only two of the proposed 24 parts appeared in print. Surprisingly, it was not until 1916 that Catharine Hodgins became the first Devon woman to contribute bird observations for publication.

Lists of spring migration dates compiled from 1840 to 1845 indicate that birds now arrive much earlier, evidence of climatic change. Some notable sightings include a flock of eight Great Bustards in 1870, never to be repeated. The Eurasian Collared-Dove first appeared in Devon, on Lundy in May 1961, only six years after the first pair had appeared in Norfolk; thus the spread across Europe preceded its recent spread across North America.

Equally interesting are occasional accounts of unusual happenings. In the winter of 1928-29, Water Rails in desperation entered into houses to take bread off tables. A peregrine found dead near its eyrie on Lundy in 1963 proved by retrospective analysis, once Derek Ratcliffe discovered the causative role of DDT and other organochlorine compounds, to be "the most chemically-contaminated individual ever discovered." (page 334).

I found the final chapter, on bird-ringing, of particular interest. David Lack, then a schoolmaster at Partington in Devon, prior to his distinguished career as a professor at Oxford University, ringed 119 adults and 121 nestling Robins on one leg and applied two coloured celluloid rings to the other leg. Many robins remained from year to year, the oldest persisting through all four years of his study. Not one was recorded outside his study area of twenty acres. His famous book, *The Life of the Robin*, told what he learned about individual robin territories and behaviour.

Ringing changed forever when the first shipment of 100 mist nets arrived from Japan in early 1956. A formal ringing station, using these nets, opened at Slapton in 1960. Jenks, a ringer himself, concludes by saying (page 390) that "ninety years of ringing in Devon has provided us with more knowledge of the county's birds than all other ornithological pursuits put together."

In summary, this book constitutes a fine and lasting contribution to the history of ornithology. Learning about past excesses can give us perspective and perhaps help us to prevent similar but different errors in future. Its widest readership will undoubtedly be in Great Britain.

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Mapper of Mountains: M. P. Bridgland in the Canadian Rockies, 1902-1930

By I. S. MacLaren, with Eric Higgs and Gabrielle Zezulka-Mailloux. University of Alberta Press, Edmonton, Alberta. 2005. 295 pages. $39.95 Can. Cloth.

This book, well written, artistically presented, and superbly illustrated, explains the history of photographic mapping in the Canadian Rockies. Complicated technical processes are clearly explained. As one would expect from Ian MacLaren, the text is enlivened by the poetry of Robert W. Service, Bliss Carman and, surprisingly, the famous Scots prose author, Sir Arthur Conan Doyle. Serious readers will appreciate the detailed information in the copious footnotes.

The subject, Morrison Parsons Bridgland (1878-1948), sometimes called Morris, but more often known as M. P., was exceedingly modest. There are no known photographs of him alone. Born on a farm on the northern outskirts of Toronto, M. P. studied engineering at the University of Toronto, and then was hired

as an apprentice land surveyor. He was remarkably fit, with incredible endurance; he once climbed 7600 feet between 2 a.m. and 11 p.m. On another occasion he spent five hours ascending the glacier on Mount Purity, but was able to glissade down in 12 minutes. He was the first to climb to the peak of 55 different mountains, and took photographs from each.

Difficult and dangerous climbs were routine. Contending with bears and snowstorms, and living frugally, M. P. became one of the foremost phototopographical surveyors anywhere in the world, taking more photographs of higher quality than anyone before him. He carried a 35-pound camera up steep mountainsides in its mahogany box, fitted into a leather case. The photographs were exposed on fragile large glass slides. An assistant carried the transit instrument (theodolite) and the tripod. Since photographs at the standard f 32 stop required a shade over the lens, a filter, and exposures of up to three seconds, absolute immobility had to be achieved in spite of insecure footing and howling winds. On each mountain top, they built a cairn, then took exquisite care in leveling the camera to define the horizon and obtain photographs in every direction, but especially to show cairns on adjacent peaks, so that angles between them could be measured precisely. A tent with absolute darkness became the darkroom to develop a few test exposures each time, but the other exposed plates were carried down the mountain side and shipped "at great expense" to Ottawa for development the following winter. Precise mathematically, there was also an obvious artistic dimension to Bridgland's work. In his Calgary office each winter, the photographs were used to construct accurate topographical contour maps. Including expenses for field and office work, Bridgland's surveys were done for half the price of those completed by others, in Jasper park for only $4.20 per square mile.

One of Bridgland's important achievements was as a founder and chief mountaineer of the Alpine Club of Canada, helping with the society's first three summer camps and writing reports for the new *Canadian Alpine Journal.* Another memorable achievement, in 1917, was his 97-page pamphlet, co-authored by Robert Douglas, secretary of the Geographic Board of Canada, *Description of and Guide to Jasper Park.* This well-written pamphlet (the design template for MacLaren's book) opened with Sir Arthur Conan Doyle's poem, the Athabasca Trail. It contained photographs of mountains, mammals and flowers, but most notably, Bridgland's striking photograph of Mt. Edith Cavell, named for the Canadian nurse shot by the German Army in World War I. The pamphlet sold for fifty cents and was reprinted many times; extant copies today fetch two hundred times the initial purchase price. A pack of six Bridgland topographical survey maps of Jasper park was also for sale, 90 cents unmounted, or three dollars mounted.

On occasion, Bridgland was treated badly by the government bureaucracy in distant Ottawa. His party often worked seven days a week, and sometimes eighteen hours a day, but a civil servant in Ottawa, perusing Bridgland's diary, noted that he had once taken one weekday off, and docked him a day's pay. At 52 years of age, after thirty years of service, Bridgland learned that his position of Surveys Engineer, Grade 4, had been abolished by the Bennett government. On 12 May 1931 he was informed that his firing would be effective on 20 May, and that he would receive only three months of retirement leave. He never fully recovered from this treatment, but the Alpine Club of Canada awarded him the prestigious Silver Rope of Leadership.

M. P. retired to Toronto where he died of leukemia in January 1948. His wife, Mary, survived another quarter century. His older son, Charles, graduated in electrical engineering from the University of Toronto. His younger son became Brigadier General Edgar Bridgland of Canadian Aviation Development fame.

In 1996, Jeanine Rhemtulla, a graduate student at the University of Alberta, began a study to re-photograph the vistas taken by Bridgland, to learn what changes had taken place. This Rocky Mountain Repeat Photography Project attracted additional helpers, including the two junior authors of this book. Photographic plates long thought to be lost were unearthed by deep historical sleuthing – and are now available for everyone to see on the web, http://bridgland.sunsite.ualberta.ca/index.html. The climax of this book is a series of photographs comparing Bridgland's 1915 photographs with those taken over 80 years later. They demonstrate how glaciers have receded and forests expanded over that long time frame.

Not only is this biography at its finest, the book is a perfect present for those interested in geography, mountains, climate change, or photography. Read it in preparation for a visit to Jasper (especially), or Banff.

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NEW TITLES

†Available for review * Assigned

ZOOLOGY

The Kingdon Pocket Guide to African Mammals. By Jonathan Kingdon. 2005. Princeton University Press: 41 William Street, Princeton, New Jersey 08540 USA. 272 pages. $24.95 Paper.

* **The Gulf of Alaska: Biology and Oceanography.** Edited by P. Mundy (Ed). Alaska Sea Grant College Program, University of Alaska, Fairbanks, Alaska 99775 USA. 214 pages. US$25.

Snakes of the Americas. By R. Tipton. 2005. Krieger Publishing P.O. Box 9542, Melbourne, Florida 32902-9542 USA. 428 pages. US$94.50.

A New World of Animals – Early Modern Europeans on the Creatures of Iberian America. By Miguel de Asúa and Roger French. 2005. Ashgate Publishing Company, P.O. Box 2225 Williston, Vermont 05495-2225 USA. 276 pages. US$89.95 or £50.00 Cloth.

Arrivals and Rivals: A Birding Oddity – A Year of Competitive Twitching. By Adrian Riley. 2005. NHBS Environment Bookstore, 2-3 Wills Road, Totnes, Devon TQ9 5XN United Kingdom £7.99, US$15.

An Atlas of the Geographic Distribution of the Arvicoline Rodents of the World (Rodentia, Muridae: Arvicolinae). By G. Shenbrot and B. Krasnov. 2005. Pensoft Publishers, Acad. G. Bonchev Street, Bl. 6, 1113 Sofia, Bulgaria. 350 pages. EURO 77.90 Cloth.

Retracing the Aurochs: History, Morphology and Ecology of an Extinct Wild Ox. By Cis van Vuure (University of Wageningen, the Netherlands). September 2005. Pensoft Publishers, Acad. G. Bonchev Street, Bl. 6, 1113 Sofia, Bulgaria. 424 pages. EURO 67.90 Cloth.

A Field Guide Amphibians and Reptiles of Bali. By L. McKay. 2006. Krieger Publishing, P.O. Box 9542, Melbourne, Florida 32902 USA. No details available.

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Birds Britannica. By Mark Cocker and Richard Mabey. 2005. Random House of Canada Limited, 2775 Matheson Boulevard East, Mississauga, Ontario L4W 4P7 Canada. 484 pages. $95.00 Cloth.

Bird Coloration. Edited by G. Hill and K. McGraw. 2005. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138 USA. 496 pages. US$95.

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Portraits of the Bison – An illustrated Guide to Bison Society. By W. Olsen. 2005. University of Alberta Press, Ring House 2, Edmonton, Alberta T6G 2E1 Canada. 120 pages. Can. $39.85 Paper.

Fauna Britannica. By Stefan Buczacki. 2005. Orion Publishing Group, Orion House, 5 Upper Saint Martin's Lane, London, WC2H 9EA United Kingdom. £18.99, approximately $35/29 Paper.

Biomes of Brazil. An Illustrated Natural History. By F. Por, V. Imperatriz-Fonseca, and F. Lencioni. 2005. Pensoft Publishers, Sofia-Moscow. 208 pages. Euro 39.50 Cloth.

Caterpillars of Eastern North America: A Guide to Identification and Natural History. By David L. Wagner. 2005. Princeton University Press, 41 William Street, Princeton, New Jersey 08540 USA. 496 pages. US$29.95 Paper, $60.00 Cloth.

100 Caterpillars – Portraits from the Tropical Forests of Costa Rica. By J. Miller, D. Janzen and W. Hallwachs. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138 USA. 300 pages. US$39.95.

Field Guide to the Bumblebees of Great Britain and Ireland. By Mike Edwards and Martin Jenner 2005. Ocelli Limited, 19 Church Street, Willingdon Village, Eastbourne, East Sussex BN20 9HR. 108 pages. £9.99 plus £1.50 shipping.

*** Crows – Encounters with the Wise Guys.** By Candace Savage. 2005. Greystone Books #201-2323 Quebec Street, Vancouver, British Columbia V5T 4S7 Canada. 113 pages. $27 Cloth.

Dodo: The Bird Behind the Legend. By Alan Grihault 2005, Imprimerie & Papeterie Commerciale Ltd Distributed by NHBS, 2-3 Wills Road, Totnes, Devon TQ9 5XN United Kingdom. 171 pages. £16.99.

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Fire Ants. By W. Tschinkel. 2005. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138 USA. 720 pages. US$95.

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Hummingbirds of Costa Rica. By M. and P. Fogden. 2006. Firefly Books, 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 154 pages. $49.95.

Identify Yourself: The 50 Most Common Birding Identification Challenges. By Bill Thompson III and the editors of Bird Watcher's Digest. 2005. Houghton Mifflin Company, 215 Park Ave. South, New York, New York 10003 USA. 416 pages. US$19.95 Paper.

Insects: Their Natural History and Diversity. By S. Marshall. 2006. Firefly Books, 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 704 pages. $95.00.

The Other Insect Societies. By J. Costs. 2005. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138 USA. 602 pages. US$59.95.

A Walk Around the Pond – Insects in and over Water. By G. Waldbauer. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138 USA. 258 pages. US$22.95.

† **For the Love of Insects.** By T. Eisner. 2005. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138 USA. 448 pages, US$16.95 Paper.

Kaufman Field Guide to Insects of North America. By Kenn Kaufman and Eric Eaton. 2006. Houghton Mifflin Company, 15 Park Avenue South, New York, New York 10003 USA. 384 pages. US$18.95 Paper.

In Search of the Ivory-Billed Woodpecker. By Jackson, Jerome. 2004. Houghton Mifflin Company 215 Park Avenue South, New York, New York 10003 USA. 294 pages. US$24.95.

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Birds of Kuwait: A Portrait. By Abdullah Alfadhel. 2005 Kuwait Environment Protection Society c/o NHBS 2-3 Wills Road, Totnes, Devon TQ9 5XN, United Kingdom. £29.95, approximately $56/45.

Mako Sharks. By A. De Maddelena, A. Preti, and R. Smith. 2005. Krieger Publishing, P.O. Box 9542, Melbourne, Florida 32902 USA. 72 pages. No price available.

Birding North Carolina. By Marshall Brooks, Mark Johns and Carolina Bird Club members. 2005. Globe Pequot Press, 246 Goose Lane, P.O. Box 480, Guilford, Connecticutt 06437 USA. 224 pages. U.S.$12.95 Paper.

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Birds of Washington. By T. Wahl, R. Wahl, W. Tweit, and S. Miodinow. 2005 Oregon State University Press, 102 Adams Hall, Corvallis, Oregon 97331 USA. 448 pages. US$65 Cloth.

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The San Diego County Bird Atlas. By Philip Unitt. 2005. Ibis Publishing Company, 44970 Via Renaissance, Temecula, California 92590 USA. 645 pages. US$80.00 Cloth.

† **Secret Weapons.** By T. Eisner, M. Eisner, and M. Siegler. 2005. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138 USA. 372 pages. US$29.95 Cloth.

Where to watch birds in Spain. The 100 best sites. By José Antonio Montero. March 2006. Lynx Edicions, Montseny, 8, 08193 Bellaterra, Barcelona, Spain. 362 pages. US$32.50 Paper.

Rodents and Lagomorphs of BC. By D. Nagorsen. 2005, Royal BC Museum, 675 Belleville Street, Victoria, British Columbia V8W 9W2 Canada. 410 pages.

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* **Wildlife Demography – Analysis of Sex, Age, and Count Data.** By John Skalski, Kristin Ryding, and Joshua Millspaugh. 2005. Elsevier Canada,1 Goldthorne Avenue, Toronto, Ontario M8Z 5S7 Canada. 656 pages. US$69.95 Cloth.

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Flowers of Crete. By John Fielding and Nicholas Turland. 2005. Kew Publishing, Royal Botanic Gardens, Kew, Richmond, Surrey TW9 3AB United Kingdom. 2005. 650 pages. £47.00, US$86.00 Cloth.

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New Flowering: 1000 Years of Botanical Art. By S. Sherwood. 2005. NHBS Environment Bookstore, 2-3 Wills Road, Totnes, Devon TQ9 5XN United Kingdom. £20 U.S.$36 Paper.

Orchids of Britain and Ireland – A Field and Site Guide. By Anne Harrap and Simon Harrap NHBS Environment Bookstore, 2-3 Wills Road, Totnes, Devon TQ9 5XN United Kingdom. £29.99, U.S.$53 Paper.

Orchids of the British Isles. By M. Foley and S. Clarke. 2006. Griffin Press. Level 13, 67 Albert Avenue Chatswood, New South Wales 2067, in association with the Royal Botanic Garden Edinburgh. 320 pages. £45.

Savannas and Dry Forests: Linking People with Nature. By J. Mistry and A. Berardi, 2006. Ashgate Publishing Company, Suite 420, 101 Cherry Street, Burlington, Vermont 05401-4405 USA. 286 pages. US$114.95.

The Wild Flower Key – How to identify wild flowers, trees and shrubs in Britain and Ireland. By Francis Rose and Clare O'Reilly. March 2006 Frederick Warne Books – Distributed by NHBS, 2-3 Wills Road, Totnes, Devon TQ9 5XN United Kingdom. 480 pages. £14.99.

MISCELLANEOUS

Dry – Life without Water. By E. Masood and D. Schaffer. 2005. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138 USA. 174 pages. US$29.95.

The Emirates: A Natural History. Edited by Peter Hellyer and Simon Aspinall. 2005. Trident Press Distributed by NHBS, 2-3 Wills Road, Totnes, Devon TQ9 5XN, United Kingdom. 428 pages, £65.00.

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*** A New World of Animals – Early Modern Europeans on the Creatures of Iberian America.** By Miguel de Asúa and Roger French. 2005. Ashgate Publishing Ltd., Gower House, Croft Road, Aldershot, Hampshire GU11 3HR United Kingdom. 276 pages. US$89.95, £50.00 Cloth.

*** Mapper of the Mountains: M. P. Bridgland in the Canadian Rockies, 1902-1930.** By Ian S. MacLaren. 2005. University of Alberta Press, Ring House 2, University of Alberta, Edmonton Alberta T6G 2E1 Canada. 576 pages. $39.95 Can. Paper.

The New World Tropics – An Introduction For Naturalists Belize – Costa Rica – Trinidad. By R. Walton and G. Dodge. 2005. Milwaukee Public Museum, 800 West Wells Street, Milwaukee, Wisconsin 53233 USA. US$24.95.

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Return to Wild America – A Yearlong Search for the Continent's Natural Soul. By Scott Weidensaul. 2005. North Point Press, Farrar, Straus and Giroux, 19 Union Square West, New York, New York 10003 USA. 416 pages. US$26.00 Cloth.

Saskatchewan – Uncommon Vistas. By J. Conway. 2005. University of Alberta Press, Ring House 2, University of Alberta, Edmonton, Alberta T6G 2E1 Canada. 156 pages. $29.95.

Taxonomy and Plant Conservation. Edited by Etelka Leadlay and Stephen Jury. 2006. Cambridge University Press, Distributed by NHBS, 2-3 Wills Road, Totnes, Devon TQ9 5XN, United Kingdom. 300 pages. £70.00.

YOUNG READERS

Backyard Birding for Kids. By Fran Lee. 2005. Gibbs Smith, Publisher, P.O. Box 667 Layton, Utah 84041 USA. 64 pages. US$9.95 Paper.

News and Comment

Marine Turtle Newsletter (110)

October 2005. 26 pages: GUEST EDITORIAL: Wild and head-started Kemp's Ridley nesters, eggs, hatchlings, nesting beaches and adjoining nearshore waters in Texas should receive grater protection — ARTICLES: Strandings of Green Turtles along the Saurashtra coast, Gujarat, India — First sea turtle tagging programme in Iran — NOTES: Observations of Green Turtles in the Lakshadweep Islands, west coast of India — Gladiatorial attack on a turtle — Length-width and length-weight relationships of *Caretta caretta* from Italy, Mediterranean Sea — Tanzania turtle & dugong conservation programme — meeting reports — MTSG UPDATE — BOOK REVIEW — ANNOUNCEMENTS — NEWS & LEGAL BRIEFS — RECENT PUBLICATIONS.

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Saving the Wild: RENEW 2005

This glossy colour 20-page booklet is published by RENEW (**RE**covery of **N**ationally **E**ndangered **W**ildife) through the Canadian Endangered Species Conservation Council is subtitled: An opportunity to Participate in Species Recovery in Canada. Contents: Letter from the Canadian Wildlife Directors — An introduction to the recovery of wild species in Canada — Everyone can contribute to saving the wild — How recovery works in Canada — Support is crucial in getting the job done — Recovery successes — Get invoved with saving the wild. Visit website www.speciesatrisk.gc.ca.

For copies, other REWEW publications, or more information contact RENEW@ec.gc.ca; telephone (819) 997-8507; fax (819) 994-3684.

It should be noted that the transforming frog (top centre among the eight photographs on the cover) although identified on the inside front cover as "Northern Cricket Frog (Endangerd)", appears to lack Cricket Frog characteristic markings and pointed snout but shows more resemblance in head shape to a *Rana*, and may instead be a common Green Frog *R. clamitans*.

Canadian Species at Risk August 2005

Issued by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), the list is 64 pages containing: ABOUT COSEWIC: mandate, membership, definitions — SUMMARY TABLES: 500 species designated in the categories Extinct (13), Extirpated (22), Endangered (184), Threatened (129) and Special Concern (152). In addition, 187 species have been considered but found to be "Not at Risk" (148), or "Data Deficient" (39) (Tables 1-3) — Results of May 2005 COSEWIC meeting (Tables 4-5) — Explanation of status change symbols for reassessed species — COSEWIC ASSESSMENT RESULTS — Table 6: Species assessed and designated Extinct — Table 7: Species placed in a "risk category" — Table 8, Species assessed and assigned to the "Not at Risk" category — Table 9. Species considered and placed in the Data Deficient category — Record of Status Re-examinations — Record of Name Changes — Names previously used by COSEWIC and synonyms.

Copies of this publication are available from COSEWIC Secretariat, c\o Canadian Wildlife Service, Environment Canada, Ottawa, Ontario K1A 0H3. See Web site: www.cosewic.gc.ca. COSEWIC Status Reports are available from the Species at Risk Act (SARA) Public Registry www.sararegistry.gc.ca.

The Ottawa Field-Naturalists' Club Awards for 2004

Irwin M. Brodo, Christine Hanrahan, Beverly McBride, and Eleanor Zurbrigg

At the Club's Annual Soirée, held on 30 April 2005, at St. Basil's Church in Ottawa, awards were once again given to members, and one non-member, who distinguished themselves by accomplishments in the field of natural history and conservation, or by extraordinary activity within the Club. There isn't always a winner for every potential award, and this year, once again, the Anne Hanes Natural History Award was not given. On the other hand, a new award was approved by Council and awarded for the first time this year: The Mary Stuart Education Award. More is said about the award in the citation below. The following citations for those who received an award were read to the members and guests assembled for the event.

Charles D. Bird – Honorary Member

Honorary membership in the Ottawa Field Naturalists' Club is given to members or non-members in recognition of their many years of service to the Club or for their contributions to Canadian natural history. Our newest honorary member, Dr. Charles D. Bird, is a retired cattle farmer from Erskine, Alberta, but qualifies for the honour on both counts. On the face of it, that might seem a little strange, but, as you will see, this is no ordinary cattle farmer.

Although his family roots were in the central Canadian prairies, Charley Bird was born in Oklahoma. He developed a love of the natural world at an early age, no doubt due at least in part to his father, Ralph Durham Bird, an entomologist/naturalist who was teaching at the University of Oklahoma at the time, and his mother, Lois, who was a botanist. From the age of 10 through his college years, Charley followed his father's interests in insects. He later worked with the Northern Insect Survey and then in the field of forest entomology. At the University of Manitoba, he became fascinated with plant ecology and turned to the study of plants. Charley developed a strong interest in mosses at Oklahoma State University where he was doing graduate studies, taking courses from the bryologist, Dr. G. K. Ikenberry, eventually earning a master's degree and Ph.D. He returned to Canada in 1960 for a post-doctoral position at the University of Alberta in Edmonton, mainly studying mosses. Two years later, he accepted a position in the Biology Department at the University of Calgary, turning his attention to the bryophytes, lichens and vascular plants of Alberta and, indeed, all the prairie provinces. At the university, Charley taught courses on all these subjects as well as biogeography, and he curated the growing herbarium as well. His research interests were principally in lichen and bryophyte ecology and taxonomy, and Charley published dozens of papers on mosses, lichens and flowering plants in scholarly journals such as *The Bryologist* and *Canadian Journal of Botany,* and our own *Canadian Field-Naturalist.* He also became involved in Alberta conservation issues and joined local natural history clubs such as the Calgary Field Naturalist's Society and Federation of Alberta Naturalists. In 1978, he received the Lauran Goulden Award for being the outstanding naturalist in Alberta that year. With a strong interest in the local flora and fauna, Charley published articles on a variety of subjects in the *Blue Jay,* the *Calgary Field Naturalist* and the *Alberta Naturalist,*. He has, in fact, published close to 300 scholarly articles in all.

Although Charley decided to take early retirement in 1979, trading in his academic tweeds for Alberta denim to become a cattle farmer, he never set aside his love of the natural world, his commitment to conservation, or his interest in high quality scientific publication. He therefore has maintained a close association with his local Buffalo Lake Naturalists Society, and he stayed on as an Associate Editor of *The Canadian Field-Naturalist*, a job he began in 1974 and continues to this day, contributing over 30 years of service to the Ottawa Field-Naturalists' Club. In the post-University years, Charley's interests returned to insects, especially butterflies and moths, and he became a major contributor to the beautiful and encyclopedic book, *Alberta Butterflies*, published in 1995. At the present time, Charley is working on a catalogue of the micro-moths of southern Alberta.

For his achievements in teaching and research, the Alberta Society of Professional Biologists presented him with the J. Dewey Soper Award in 2000, also making him an Honorary Life Member of that society.

Whether he is cataloguing mosses, studying the taxonomy of a lichen genus, working on the phenology of flowers, collecting, mounting and identifying hundreds of species of tiny moths, tracing his family's genealogy, or, indeed, keeping records of cattle breeding, Charley is always meticulous, thorough, imaginative and perceptive... a naturalist's naturalist. We are therefore proud to add Charley Bird to our roster of distinguished Honorary Members.

Barbara Barr – Conservation Award (Non-Member)

The OFNC Conservation Award – Non-Member is given in recognition of an outstanding contribution by a non-member in the cause of natural history conservation in the Ottawa Valley, with particular emphasis on activities within the Ottawa District.

Barbara Barr is a very worthy recipient of this award in recognition of her outstanding efforts in speaking on behalf of natural area protection in the Ottawa area through the Regional and municipal planning processes. Barbara is an active, dedicated and highly credible representative for the Greenspace Alliance of Canada's Capital as well as for the South Keys/Greenboro Community Association.

The thorough, intelligent work that Barbara does reflects her excellent grasp of environmental issues in the Ottawa area as well as her grasp of the way the City works. She is able to be highly effective, for example at meetings of the City of Ottawa's Planning and Environment Committee, by accessing information, preparing and presenting thorough briefs, following-through on outcomes of presentations, and providing a reliable and reputable source of sage advice to policy makers on natural area conservation issues. In this way, she is a highly effective participant during the public consultation phases of land development proposals, a voice that the conservation community can be proud to have speaking on its behalf. Public officials appreciate the value that she adds to the public consultation process and have invited her to participate on various Public Advisory Committees.

Barbara's frequent interventions at planning meetings have served to:

- sustain the importance of natural area conservation in the minds of elected officials, by keeping it a visible issue;
- raise the consciousness of Councilors on specific issues, such as how destructive country lot subdivisions are to Rural Natural Features;
- re-enforce with City staff and Councilors alike the importance of a good Planning Process, and of honoring the commitments, intent and spirit of the Official Plan with respect to Environmental Features and Environmental Impact Statements;
- demonstrate the value-added of public consultation and participation in the planning process (seek win-win solutions); and
- influence decisions being made on various land use proposals.

Barbara's interventions have covered a suite of topics, ranging from specific conservation issues such as protection of the Montfort Woods and Leitrim wetland parcels and the Alta Vista Transportation Corridor, to more general topics including proposed rural developments for country lot subdivisions, suggestions to improve the City's planning process and documents and the Urban Natural Areas Environmental Evaluation Study.

One of Barbara's important characteristics is her optimism and determination to stay with the process. With economic and land development activities booming in the Ottawa area, it takes solid, reasonable, informed contributions to influence the process and to advocate for Smart Growth.

Through this award, OFNC members recognize the outstanding efforts of Barbara to influence Regional and City planning decisions to include natural area conservation.

Ghislaine Rozon – Conservation Award (Members)

The OFNC Conservation Award is given in recognition of a club member who has made an outstanding contribution toward protecting our natural environment. Ghislaine Rozon is a remarkable woman who more than fits this criterion. She is a dynamic, articulate, passionate defender of our local greenspace, particularly the Larose Forest. She has worked non-stop trying to preserve this area as a conservation zone, free of development.

Her battle for the forest began in the summer of 2002 when, newly retired from a long teaching career, she discovered that a development proposal for Larose Forest was being given serious consideration by the United Counties of Prescott-Russell (UCPR). Aghast at what this would do to the natural environment of the forest, she threw herself into the fight. She contacted the OFNC Conservation Committee for advice, but quickly perceived that she would need a thorough understanding of municipal, provincial and federal politics, including a good knowledge of the Planning Act, if she was to argue with elected officials on the necessity of conservation. Then she realized she would need to educate herself in the areas of forestry, hydrology and ecology. All of this she did with tremendous competence and customary thoroughness. As Ghislaine immersed herself in learning everything there was to know about the political process, including the Provincial Policy Statement, Environmental Assessments and related acts, the boxes of files, papers, articles, reports and letters grew. Her home became "Command Central" for those who were adamant that the forest must be preserved. Through detailed reading of numerous documents, she exposed inconsistencies and inaccuracies in the material produced to support development in the forest.

She also knew that gaining public support was extremely important and rallied both residents and various conservation groups to the cause. "The Friends of Larose Forest" which existed prior to the controversy, was revived and with Ghislaine, presented a united front for a development-free Larose. She also contacted politicians at all levels, as well as the various

media, offering guided tours of the proposed development site so that they could see it for themselves and make up their minds based on facts, not hearsay.

Anyone who has dealt with Ghislaine over the last few years knows that it is not unusual to receive e-mails written and fired off at 2, 3 or 4 in the morning! It appeared that she never slept! These detailed messages... lucid, well-reasoned, intelligent and thought-provoking... were regularly mailed to a growing list of supporters. Suggestions on how people could help, lists of addresses for the relevant government officials, sample letters, as well as succinct synopses of many relevant reports, all were supplied by Ghislaine who became the acknowledged and reasoned voice for saving Larose Forest.

As a last resort, Ghislaine and several others appealed the issue to the OMB. This was not a step lightly undertaken. The cost for hiring a lawyer and expert witnesses was substantial and was absorbed by the appellants. In the end the decision was handed down in favour of the developers. Despite this crushing blow, Ghislaine has not given up her fight to save the forest. As she has done from day one, she continues to explore ways in which Larose Forest can be preserved as a conservation area, remaining vigilant and alert to all threats to this special place. Brimming with ideas, she has plans for a website, printed resource material and possibly an interpretive centre ... this lady is amazing! If ever there was an example of how to go about preparing to protect natural areas, one need look no further than Ghislaine for inspiration, which is why the Club awards her the 2004 Conservation Award for Members.

Martha Camfield – George McGee Service Award

The OFNC George McGee Service Award is given in recognition of a member who has contributed significantly to the smooth running of the Club over several years. Martha Camfield is a very worthy recipient of this award in recognition of her extraordinary service over many, many years as a dedicated volunteer with the Macoun Field Club. Martha has also readily volunteered to assist with numerous plant surveys and inventories in the Ottawa area, and has served on Council.

For many years – as long as many of today's young Macouners remember and longer – Martha has been a dynamic force with Macoun Field Club and the committee that manages it. She has readily volunteered in many capacities with the young naturalists, frequently serving as a leader for meetings, workshops and field trips, and also working to find speakers and leaders for weekly meetings and field trips.

Martha's great "hands on" discovery workshops are a particular favourite of the Macouners. Each workshop is uniquely researched and supported by plentiful plant materials that Martha has collected for dissection or identification – whether it be a variety of roots, seeds, wild flowers, leaves, fruits, shrubs, sedges, exotic plants, and more.

Martha commands instant respect from the young people, who respond to her curiosity and whole-hearted enthusiasm to share and impart some of the truly amazing nature of her subject. Interesting materials coupled with good basic instruction on how to use a hand lens or microscope leads to ready involvement of the young people so that by the end of a workshop everyone has dirty fingernails and a much better idea of how leaves and seeds and roots function. At one session on horsetails, she burned the ends of the plant stalks to show how the silica inside would form "glass-like beads" on the ends. When studying seeds, the air became delightfully filled with cattail fluff! A testimony to Martha's impact is most appropriately captured in the words of one of her workshop participants, who said, "I think that the most important thing that Martha taught us was the wonder that can be in just one seed. Thank you Martha! We all had a fantastic time."

As a Macoun field trip leader, Martha had a genuine interest in what each young person was finding, hoping to further spur his or her curiosity and interests. One of Martha's gifts is to help wake people up to the world around them by making the outings and information imparted relevant to them.

Another facet of Martha's long-time volunteerism for The Ottawa Field-Naturalists' Club has been through her ready assistance on botanical surveys and inventories of natural areas around Ottawa, most notably with Albert Dugal. Martha's love of the outdoors, of nature and of plants in particular, and her remarkable energy, make her a natural at this. Martha has spent many days helping Albert Dugal – walking, collecting and listing plant species as part of inventories or surveys of a long list of natural areas, including the Leitrim wetlands, Spring Hill Bog, Poor Quarry Woods, Canadian Museum of Nature lands in Aylmer, Fern Bank Wetland and the woodlands east of the Ottawa Hospital complex at Smythe Road. Most recently, she has been working on an inventory of old growth species in Emerald Woods, and wetlands that are part of the historic Leitrim Complex.

This truly remarkable service over many years is most deserving of the George McGee Service Award. Thank you, Martha.

Andrea Howard – Mary Stuart Education Award

Andrea Howard, Education Coordinator of the Eastern Ontario Biodiversity Museum (EOBM), has been chosen to be the first recipient of the Mary Stuart Education Award for her outstanding, innovative approaches to teaching a variety of natural history topics. This new award has been established for members, non-members or organizations in recognition of outstanding achievements in the field of natural history education in the Ottawa Region. The new Education Award was appropriately named in honour of Mary Stuart, who was so passionately interested in establishing a new generation of young naturalists.

Andrea Howard is a very gifted, knowledgeable and effective teacher who has been the education coordinator at the EOBM in Kemptville ever since the museum came into being over five years ago. In that capacity she has developed innovative natural history programs presented at the museum and at various venues around the North Grenville community and in Ottawa. Andrea brings to her position of education coordinator a unique background in classroom teaching, science (B.S. from Queen's University), drama (B.A. from Queen's University, and active in a local theatre group) and environmental advocacy (worked for Pollution Probe).

Andrea has developed her own series of creative, exciting and accurate biodiversity modules, collectively called "Museum in a Suitcase" which she brings into various classrooms or classroom-like situations. These programs include "Secret Life of the Forest" (the biodiversity of decomposition), "Climate Change" (biodiversity and global warming), "Life Cycles & Seasonal Adaptations" (biodiversity of survival), "Introduction to Taxonomy" (classification of biodiversity) and "Bugwatch/Insects" (biodiversity of insects). Andrea skilfully adapts each program to the particular teacher and classroom situation by consulting with the teacher in question. The literacy program that Andrea created and implemented for local high school students having reading difficulties is something that the EOBM is particularly proud of. The subject matter employed was, of course, natural history.

The need for training teachers has not escaped Andrea's attention either. She has developed and implemented professional development programs for teachers, helping them also to explore the possibilities of the immediate neighbourhood, especially the school grounds.

Andrea always seeks to learn more by asking appropriate professionals for help and advice and having them review her syllabus. She reads constantly to upgrade her knowledge and all of this is reflected in the timely and lively content and presentations in her classes. She has an excellent rapport with her students and their teachers. For all the above reasons and many more, we have chosen Andrea Howard for the Education Award.

Marilyn Ward – Member of the Year

The OFNC's Member of the Year award recognizes the member judged to have contributed the most to the club in the previous year. Marilyn Ward is the kind of member whose efforts keep things humming quietly but surely along. In 2004 Marilyn was particularly busy making significant contributions on at least three fronts.

Anyone who has called the club's phone number recently has spoken with Marilyn. The OFNC has a phone number, but it doesn't have an office. Incoming calls have to go somewhere! For the last four years, they've gone to Marilyn or to an answering machine in her front hallway. Whether she gets the message by machine or in person, she is a welcoming greeter who efficiently answers questions or connects callers — be they out-of-town visitors, members or prospective members — with the person who can answer their question. We know her hospitality extends beyond the phone too. She even arranges to meet new members at a monthly meeting in order to personally welcome them and to hand them their membership packages, which she also compiles. The club's e-mail address also leads to Marilyn.

Marilyn is a valuable member of the Excursions and Lectures committee. She is conscientious and reliable, and she cares about details. As any field trip leader will tell you, she is good at recruiting field trip leaders. She also phones leaders and speakers in advance of their commitments to make sure they haven't forgotten — a service much appreciated by club members. Not only that, she personally shows up at almost every field trip and monthly meeting where she helps out with logistical details.

The Fletcher Wildlife Garden gets a lot of traffic, with committee and council meetings, volunteers and visitors. Somehow, amazingly, it almost always looks neat and tidy. Of course all users are expected to clean up after themselves, but we all know this sort of thing works better in theory than in practice. Marilyn has been described as a fiend when it comes to keeping the Fletcher centre orderly! She's often there at least twice a week. She also provides suet cakes for the Fletcher bird feeding stations and makes regular walks around the whole site to see what birds are around.

Handling the club phone, helping to make sure events are successful, keeping the place spic and span: we can't underestimate the importance of these contributions as part of the public face of the club. Marilyn, the club is grateful for your many special contributions during 2004. Designating you as Member of the Year is our way of saying, " Thank you!"

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